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## Theory Pack 2

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# 1 Computer-readable forms

Data capture on a hand-completed form has two disadvantages. The process of completing the form is slow and the data then has to be prepared by copying it to a computer-readable medium. This not only slows things down further, but it also introduces the possibility that data might be incorrectly copied when it is being prepared. There are also additional running costs in data preparation, since staff have to be employed to copy the data from the source document to a computer-readable form.

Automatic data capture, where the source document is either completely or partially in computer-readable form, is now the normal method, except for very small-scale operations where the amount of data collected means that manual methods are more cost-effective.

Some of the advantages and disadvantages of computer-readable data capture forms are as follows:

- ✓ Data input is faster.
- ✓ No data preparation staff are needed, so running costs are reduced.
- ✓ No data preparation means there are fewer stages in which errors can be introduced.
- ✗ Damaged forms may be unreadable by the hardware so some manual input will still be needed.
- ✗ There will be costs involved in setting up the system. Both hardware and software will be needed.

There are a number of different ways of making the data computer-readable. These are described below.

## Optical mark reader (OMR)

In the case of an optical mark reader, the user indicates data by making a mark on a special pre-printed form. This method is used for national lottery tickets and for multiple-choice examinations. Some hospitals use OMR to allow patients to mark which of several meals they want to order.


The completed form is scanned and the presence or absence of a mark in a predetermined spot on the form is noted by reflecting infra-red light off the spot. The form usually has special marks printed in black along one side so that the scanner can determine exactly which part of the form is being scanned. The rest of the form is printed in pale blue or red which does not affect the way the light reflects off the form and so does not interfere with the scanning process. The optical mark reader scans for marks at definite points on the form so it must be accurately printed, hence the forms can be expensive.

For small volume applications, forms can be fed into a scanner by hand, as for national lottery tickets.

If there is a large number of forms then an automatic feed mechanism allows the forms to be fed into the scanner. Once they have passed through the scanner, the forms are collected into one of two containers. One holds the forms that have been successfully scanned and the other holds those where the form could not be read or where some other error occurred. Data from these forms is then entered manually.

Although OMR forms allow data to be input quickly, they do limit the type of data that can be collected. They are ideal for situations where simple choices or selections are being made or when the data that is being collected can take one of several possible known values.

Some of the advantages and disadvantages of OMR are as follows:

- ✓ The form is simple to understand and data entry is easy.
- ✓ The form can be read very quickly.
- ✗ The user must use soft pencil or an ink that the scanner can detect.
- ✗ The forms are expensive.
- ✗ Only limited types of data can be collected.
- ✗ Creased or dirty forms cannot be read.

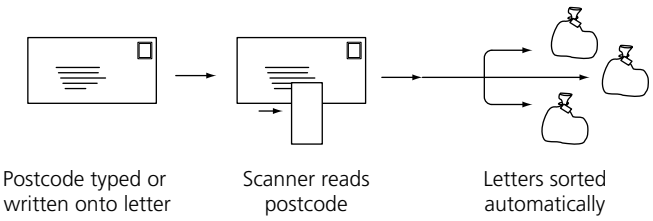
## Optical character recognition (OCR)

An optical character recognition system recognises individual characters by the way each reflects light. Many scanners used for inputting pictures also have OCR software which allows them to scan and read printed text. Note that OCR software is processing the scanned image to identify each character individually. The result is a text file, not a picture file. The output can be loaded into a word processor and edited.

OCR scanners and software cannot always distinguish between, for example, zero and the letter O or between one and the letter l. If accuracy is important then a special OCR font can be used, as shown in the example below:

| Times New Roman Font | ◊CR Font |
|---|---|
| Zero is 0 and the letter is O.<br>One is 1 and the letter is l. | Zero is ◻ and the letter is ◊.<br>◊ne is ⅼ and the letter is l. |

OCR is used where there are large volumes of printed text to input. One application is in reading postcodes on letters at sorting offices so that letters can be sorted automatically. It is also used together with speech synthesis hardware and software to read documents for blind people.




Some of the advantages and disadvantages of OCR are as follows:

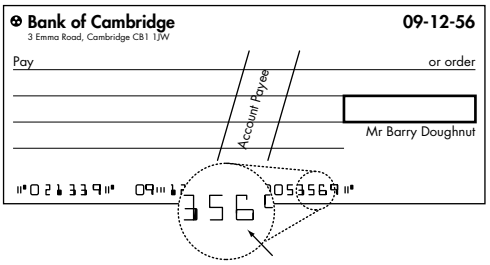
- ✓ The form is in an understandable format.
- ✓ Data input is faster than typing the text.
- ✗ Errors may occur unless a special font is used.
- ✗ Only typed or printed text can be read.
- ✗ Creased or dirty documents cannot be read.

## Magnetic ink character recognition (MICR)

Magnetic ink characters are printed using special ink. The ink affects a magnetic field and, when each character is placed in a magnetic field, it influences the field in a way that is unique to that character. The characters can therefore be 'read' by the changes that each one causes to a magnetic field.

Magnetic ink characters are printed in a special character set to ensure that each one has a different effect on the magnetic field when it being read. This allows MICR documents to be read both accurately and quickly.

MICR documents can be read even when the source document is dirty or overwritten with ordinary ink. However, the ink and machinery needed to print magnetic ink characters are expensive. The only real application of MICR is in banking where MICR characters are printed on the bottom of cheques giving the cheque number, the account number and the branch sort code number. These numbers are all printed before the cheque book is issued.



Characters written in magnetic ink

When the cheque is used, the person who has been given it will present it at a bank. The bank will use an MICR printer to put the amount of money on the cheque. When the cheque is read by the computer, it contains all the data needed to debit the amount from the cheque writer's account. The number of cheques that have to be processed each day is so great that it would be impossible to process them all without some form of automation.

The accuracy and speed of reading, combined with the fact that documents can be read when overwritten or dirty, outweigh the additional cost involved. There is also the additional benefit that it is difficult to alter MICR characters so the possibility of fraud is reduced.

Some of the advantages and disadvantages of MICR are as follows:

- ✓ The data is in an understandable format.
- ✓ Accurate data input, thus there are few reading errors.
- ✓ Dirty and overwritten documents can still be read.
- ✓ Documents are difficult to alter, hence there is a reduced chance of fraud.
- ✗ Printing is expensive.
- ✗ Creased or torn documents will not pass through the reader.

## Magnetic strip cards

Magnetic strip cards are plastic cards with a magnetic strip embedded on the back. The magnetic strip stores data. The cards are widely used for credit cards and for store loyalty cards.


A magnetic strip credit or cash card stores the account number and expiry date of the card together with security data. It also stores data identifying what type of card it is.

When the card is used to obtain cash at a cash point or automatic teller machine (ATM), the card details are read and transmitted to the bank's computer. The user is asked to enter a Personal identification number (PIN) on the ATM terminal's keypad. The PIN is transmitted to the central computer which checks that this PIN is correct for the account number that was read from the card. If the match is correct then the user can proceed to enter the amount of cash required and the transaction proceeds. Note that since it is possible to read and change the data on the magnetic strip, the PIN is not stored on the card.

Some of the advantages and disadvantages of magnetic strip cards are as follows:

✓ Small, convenient size.

✓ Fast and accurate data input.

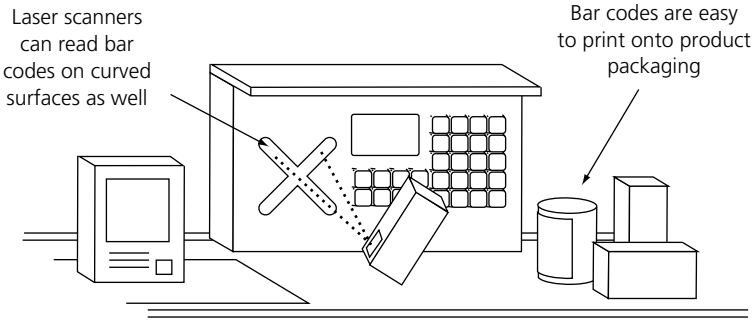
✗ Data can be accidentally wiped if the card is scratched or exposed to strong magnetic fields.

✗ The data is easily read and can be changed, so fraud can be a problem.

## Bar codes

A bar code consists of a series of thick and thin black lines. Different widths and grouping of bars represent different digits. International agreements mean that bar codes can be read consistently across the world. One of the main uses of bar codes is to identify a product by representing a product ID code. The product ID code consists of two parts: the first part is a code identifying the manufacturer of the product and the second part identifies the actual item. In addition, a bar code also contains a check digit to help reduce the possibility of invalid data being captured.

A bar code reader can read a bar code in either direction. There are three main types of bar code reader, each adapted for a particular type of use. The laser under a flat sheet of glass is used in supermarkets, for example. This allows the sales assistant to pass goods over the scanner easily.




*Bar codes being laser-scanned at a checkout till*

In libraries, a bar code is stuck inside the book. The librarian would find it difficult to open the book and pass it over a supermarket scanner, so a wand is used instead. This looks rather like a pen and it is placed on the bar code and moved over it by hand.

In DIY shops, many of the items are too large to lift and pass over a flat scanner, so a gun is used. This is pointed at the bar code label and a trigger switch clicked to read the bar code.

Bar code labels are easily produced using an ordinary printer and so a library, for example, could produce its own book labels and membership cards. The book labels would have a bar code representing the book ID and the membership card bar code would represent the membership number.

It is important to realise that the bar code can only represent a limited range of numbers. This means that while it can represent, for example, a product ID code, it cannot store any other data about the product. Bar codes do not store price or product descriptions. Information about the product is output from the computer system following the bar code input.

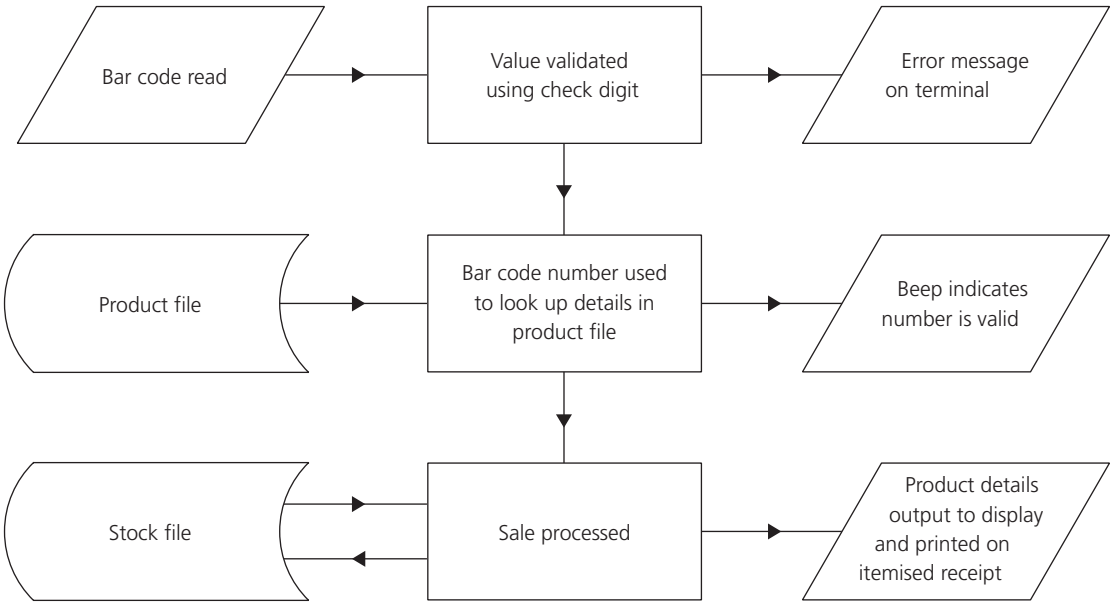
Some of the advantages and disadvantages of bar codes are as follows:

- ✓ Easily printable so customisable systems are possible.
- ✓ Variety of reading devices to suit different applications.
- ✓ Can easily be incorporated into product packaging.
- ✗ Cannot be read if dirty or overwritten.
- ✗ Limited data can be stored. Only suitable for storing ID data.

## Bar codes in supermarkets

The system flow chart on page 7 shows how a bar code system works in a supermarket.

The sales assistant passes the item over the scanner and the bar code is read. The check digit is used to validate the data. If the bar code has a valid check digit, the product file is searched to find the product that has a matching bar code number. If no match is found, the bar code must be invalid and an error message will be displayed. If the bar code is valid, a beep is sounded so that the operator knows, without having to look at the display, that the item's bar code has been successfully read.




The details found in the product file are printed on the itemised receipt and displayed on the terminal. The number of items in stock for the item being sold is read from the stock file, one subtracted from it and the new value written back to the stock file. This means that the stock file is always up to date.

The customer benefits from this system by having an itemised receipt and a shorter wait at the checkout. Because the shop's stock control is likely to be improved, since the stock file is always up to date, the customer should find that the shop does not sell out of goods and that perishable goods are fresher.

The manager benefits because better stock control means that less stock needs to be kept in the shop and the computer system can be used to reorder new stock just in time to prevent the shop selling out. This not only results in fresher goods being on display, it also reduces the amount of money tied up in stock, so reducing the shop's overheads and making it more profitable. There is no need to price goods individually, so some staffing costs are reduced.

## Smart cards

A smart card, also known as an integrated chip card (ICC), contains memory circuits that can store a great deal more data than a magnetic strip card. Smart cards are more secure than magnetic strip cards and in some countries they are used as credit cards. In the UK, magnetic strip cards curently also include the smart card chip. The card can then be used either as a magnetic strip card where the customer validates a purchase by signing a receipt, or increasingly as a chip and PIN card, where the user must enter his or her PIN to validate the purchase.


Another proposed use of smart cards is as cash stores: the user would place the smart card in a cash point machine but, instead of cash being dispensed, the smart card would be loaded up with electronic cash. The card could then be used to buy things instead of using cash.

## Appropriate hardware and software

In this chapter you have seen that a variety of methods for capturing data from a source document are available. When we looked at input and output devices in *GCSE ICT Theory Pack 1*, chapters 2 and 3, there were a number of different devices available that could be chosen to suit a particular application. The same is true of software. There are usually a number of different software packages available for a particular task.

When choosing hardware and software for a particular task, a number of factors must be considered. For example, when choosing hardware, we would need to look at:

- the volume of data that has to be input, processed and stored
- the type of data capture needed, the level of accuracy, the speed at which the data is arriving and the form of the data
- how quickly the data has to be processed
- costs – both running costs and set-up costs balanced against the benefits.

When software is being selected, we need to look at:

- functionality – does the software do all the things we need it to?
- user interface – how easy is the software to use?
- system requirements – will the software run on our existing hardware?
- cost benefit – will the cost of the software be balanced by the benefits gained?
- can existing data be converted or will it have to be re-entered manually?
- support – what sort of technical support is provided? Is there a help-line, training or online help? How readable is the user guide?

## Key points

- Forms that a computer can read directly need no data preparation and therefore reduce the chances of errors being introduced.
- Computer-readable forms allow data to be input faster than manual methods.
- Some applications deal with such large amounts of data that it would be impossible to use manual methods.
- A variety of different computer-readable formats are available.
- The actual hardware and software chosen for a particular application depends on a number of factors.

## Questions

1 MICR is used on cheques so that data can be read directly from the cheque into the computer.

a Why have banks needed to automate data capture from cheques?

b Which three items of data are coded on the cheque when the cheque book is printed?

c What additional data is coded when the cheque is processed?

d Why is MICR used for cheques, rather than the cheaper OCR?

2 OMR is commonly used to collect answers from candidates for multiple-choice examinations.
   a Give two advantages OMR has over manual marking of multiple-choice exam papers.
   b Describe one other application that uses OMR to collect data.
3 OCR is often used when large amounts of written text need to be input into a computer system.
   a What disadvantages are there to using OCR?
   b What are the advantages?
4 Bar codes are used to identify goods in supermarkets and other shops. They are also used to identify library books and goods in DIY stores. Three types of bar code reader are used, for example, a scanner in supermarkets, a wand in libraries and a gun in DIY-stores. Explain why each particular type of bar code reader is particularly suited to its application.
5 One advantage of a supermarket bar code system is that it helps manage stock levels efficiently.
   a How can more efficient stock management benefit the management of the supermarket?
   b How can it benefit the customer?
   c The customer is presented with an itemised receipt. What is an itemised receipt?
6 A supermarket chain has introduced a loyalty scheme where the customer is given a plastic card that identifies them. Each time they spend money at any branch of the supermarket, they gain points that can be traded in for goods. When they shop at the branch at which they registered for the scheme, they automatically get their points total shown at the bottom of the receipt. Points can only be traded in at the branch at which they registered.
   a In what form is the customer's ID number stored on the plastic loyalty card?
   b Where are the customer's total points earned stored?
   c How, other than helping to retain customers, does this system benefit the supermarket management?
7 Credit cards and debit cards have a magnetic stripe on the back and also have a chip to store data. Either type of card can be used at an ATM to withdraw cash.
   a What is an ATM?
   b What data is stored on the magnetic stripe and in the chip?
   c What is the difference between a credit and a debit card?
   d The ATM reads data from the stripe and the user inputs more data using keys. Give two items of data that the user must enter when withdrawing cash at an ATM.
   e Give one way in which the customer benefits from the availability of an ATM and one advantage to the management of the bank.

# 2 Files and file processing

## File access

A data file can be processed using sequential or random access, depending on the type of processing that is being done. With sequential access, the records in the file are processed in order, starting with the first and continuing through to the last. This means that the transactions that need or change the data in the file must be collected together so that they can be processed in the same order as the records.

The records in a random access file are processed one at a time, irrespective of where they are in a file. This type of processing allows the transactions that need or change the data in the file to be processed as and when they happen.

It is difficult to process a random access file sequentially. It is also difficult to process a sequential file randomly, and it will be impossible to do so if the sequential file is stored on tape.

A file that is to be accessed randomly must be stored on a medium that allows random access and it must have fixed length fields. A file that will be processed sequentially can be stored on any medium including tape and it can have variable length fields.

The type of access that will be used when a data file is processed will be decided when the computer system is designed. The choice of which type of file access to use is usually obvious. If transactions are processed all together in a batch, and most or all the records in the file will be needed or changed, then it is more efficient to process the file sequentially. If records need to be processed in any order as transactions occur, then random access will be needed.

## Important terms

There are some important terms that are used when describing the processing that can be carried out on a file. You will find the next few sections easier to understand if you are familiar with the following terms and their meanings:

- **Transaction** – A transaction is any event that makes it necessary to change the data in a file. For example, if an item is sold in a supermarket then it will be necessary to change the data in the stock file. The sale is called a transaction.
- **Updating** – This is the process of bringing the data in a file up to date so that it reflects any changes caused by transactions that have taken place since the last update. Random access files are updated as transactions occur. Sequential access files are updated when a batch of transactions have occurred and have been collected together ready for processing.
- **Sorting** – This is a process that puts the records in a file into order. It may be necessary to sort a file several times, in which case the final order of the records will depend on the order in which the different sorts were done. This can be illustrated as follows. Suppose a teacher has a database file that stores students' first names and surnames and wants to sort the file so that it is in alphabetical order of surname. The teacher also wants students with the same surname to appear in alphabetical order by first name. This order could be obtained by sorting the file in order of first name and then in order of surname. The final (surname) sort would rearrange the data so that it was in order of surname, but any records with the same surname would be left in the order of the previous sort. The diagram on page 11 illustrates this:

| Unsorted list | Step 1 List sorted by first name | Step 2 Final sort by surname |
|---|---|---|
| Becky Thompson | Alan Thompson | John Adams |
| William Brown | Andrea Brown | Andrea Brown |
| Sally Brown | Becky Thompson | Sally Brown |
| John Adams | John Adams | William Brown |
| Mary Green | Mary Green | Mary Green |
| Alan Thompson | Sally Brown | Alan Thompson |
| Andrea Brown | William Brown | Becky Thompson |

*Effect of successive sorting*

When two or more files are being processed sequentially then the corresponding records in the different files must be sorted in the same order. This is necessary for sequential access processing because it is not possible to search back and forth through the different files to find the next record that is needed.

- **Master file** – A master file is a main file in a computer system. Most data in a master file will remain unchanged by transactions, although some fields will change. Examples of master files are stock file and customer file. If we consider a record in a stock file, then when an item is sold, most of the fields will be unaffected by the sale. Only the number in stock will change. All the other data, such as bar code number, product description and so on, will remain the same.
- **Merging** – This is the process of bringing data from two files together to form a new updated file. The simplest form of merging is to add new records to the end of an existing file. This is called 'appending' and it can only be done if the two files involved contain the same set of fields or, more accurately, if all the fields in the file that is being added also exist in the file that is being added to.

  Merging results to a new file can be more complex than simply adding new records to the end of an existing file. If the two files being merged are sorted, then the new records may be slotted into place so that the new file is also sorted and contains all the records from the two original files.
- **Back-up** – This involves storing data in additional files, so that if the working files become unavailable or corrupt, they can be recreated. The method of providing back-up depends on the type of processing that is being done on the files.

## Batch processing

In a batch processing system, all transactions are collected together and stored in a special file called a transaction file. The transaction file records will include the master file key field as one of their fields – though it will not necessarily be the key field for the transaction file.

When all the transactions have been collected, the transaction file is sorted in order of the master file key field. This is essential since the two files will be sequentially processed together. Sorting the transaction file in order of the master file key field will ensure that, as data is read from the files, the next record from the transaction file matches the next record from the master file. The transaction file and the master file are then merged to create a new updated master file, together with any other output that the system is designed to produce.

Batch processing is suitable for situations where there is a lot of data to be processed and where the data can be collected together and processed all at once. It is not suitable for situations where transactions have to be processed as they occur or where the data files have to be up-to-date at all times.

## Examples

Electricity billing is a good example of an application where batch processing is suitable. Meter readers collect a large amount of data during the day. The data, which consists of account numbers and meter readings, is collected in a transaction file. The transaction file is then sorted in order of account number and merged with the customer file to produce an updated customer file and a set of bills that are posted to customers the next day.

Another suitable application for batch processing is payroll. Here data about hours worked for each employee is collected at the end of the week for input and processed as a batch to produce payslips.

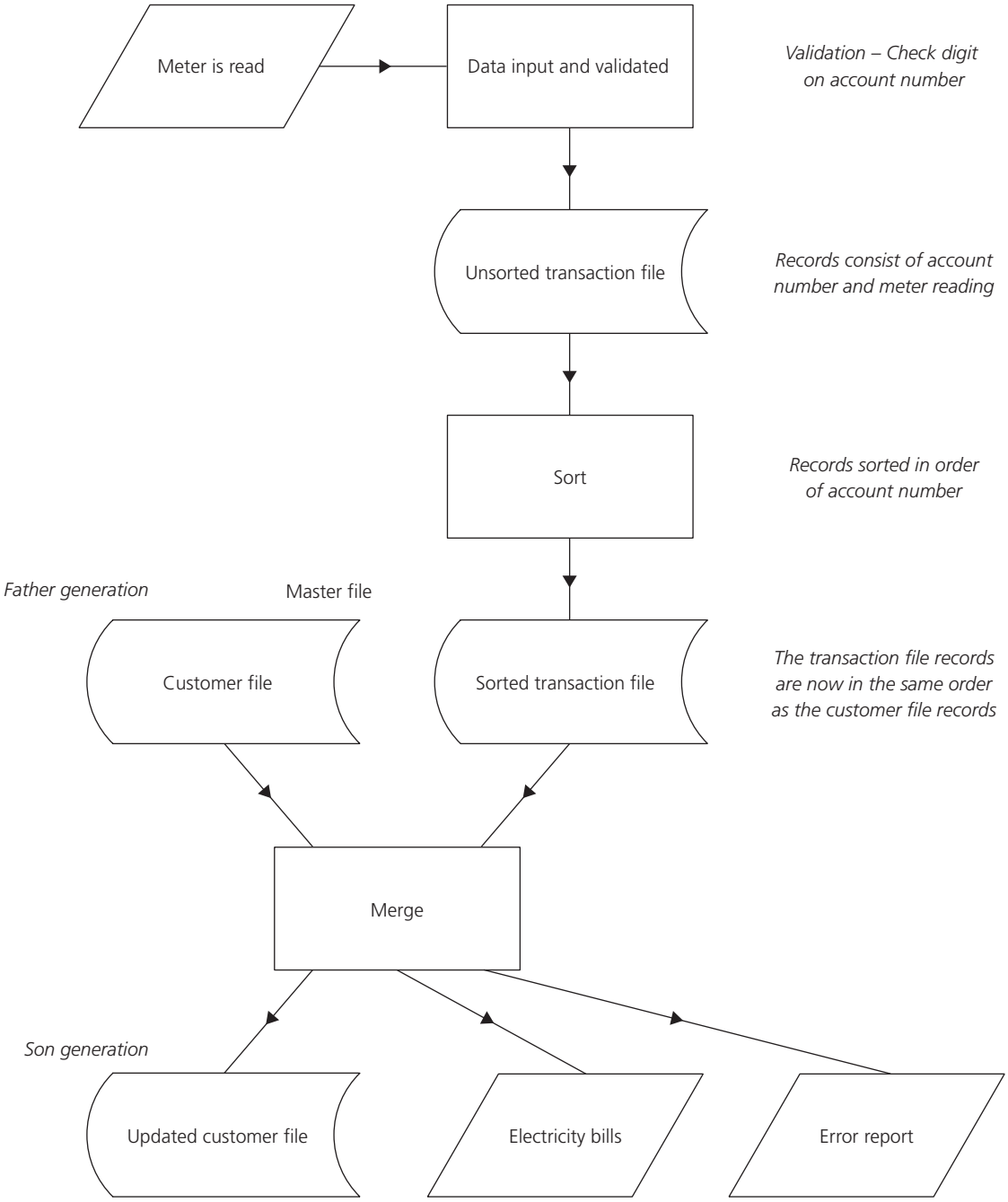
In each of these applications, every record in the file will be processed, since each customer will get a bill and each employee will be paid. This makes sequential access appropriate, as it is for all batch processing systems.

The system flow chart on page 13 shows an electricity billing system that uses batch processing.

The error report will give details of errors detected during the merge. Errors could be detected as a result of validation at any stage of the processing. One example of validation that could be carried out is to check that the current meter reading is greater than or equal to the last meter reading. An error would also be reported if an account number in the transaction file did not exist in the customer master file.

The customer file records will have the account number as the key field. Other data that must be stored if the system is to work will be the customer's name and address, so that the bill can be posted to them, and the previous meter reading, so that the amount of electricity used can be calculated. If the meter is not read, then the system will produce an estimated bill based on the amount of electricity used during the same period last year. This means that the master file must store the last four meter readings. The updated master file will store the latest meter reading.

The sorted transaction file and the father generation master file will be stored in a safe place. If the new (son generation) master file is damaged or lost, then it can be recreated by merging the two father generation files again.



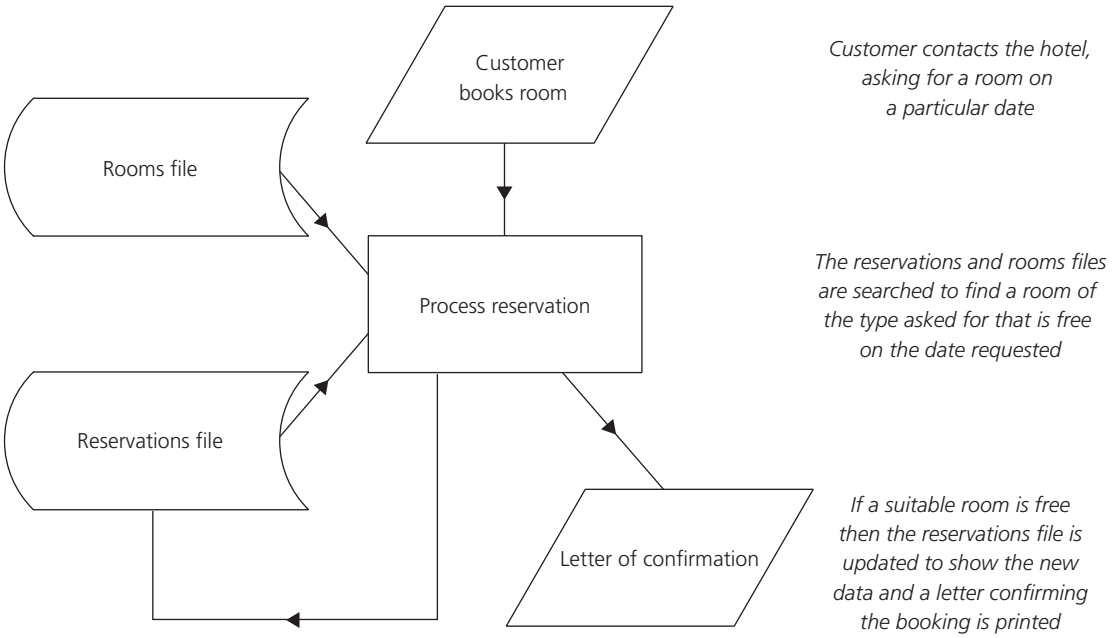

*Electricity billing system*

## Transaction processing

With transaction processing, the master file records are updated as the transaction occurs. This type of processing requires random access files, which in turn means that the records in the file must be fixed length records (see page 10). This type of system is also known as a real-time system because changes to the master file are made at the same time as the events that cause the changes. It is also known as an online system because the transaction is processed via a direct link to the computer.

Transaction processing is used when the master file needs to contain up-to-date data all the time. An example of a situation where this is necessary is a hotel room reservation system. If batch processing were used to process the reservations then it would be possible for two people to book the same room on the same date. The double-booking would not be spotted until the batch of reservation transactions was processed.

With a transaction processing system, the room would be shown as booked as soon as the booking transaction was completed. The flow chart below shows a hotel room reservation system:




*Hotel room booking system*

In a batch processing system, the master file is easily backed up by keeping the previous generation together with its transaction file. In a real-time transaction processing system, back-up is a little more complicated. We can take a copy of any of the files at a particular instant. This copy is sometimes called a 'snapshot' to emphasise that the file is constantly changing. If the file becomes corrupted or damaged then we could use the snapshot. However, any transactions that took place after the snapshot copy was made will be lost.

For proper back-up, we need to take snapshot copies of the file at regular intervals. In between snapshots, every transaction that changes the file must be copied to disk or tape. The file that stores these transactions is called a transaction log. If we need to restore the system from the snapshot copy then the snapshot can be brought up-to-date by merging it with the transaction log.

## Key points

- A number of different processes can be performed on files. These include sorting, merging and updating.
- Batch processing is appropriate for any system where transactions are collected together and dealt with in a batch. Transaction processing must be used if the main files need to contain up-to-date data at all times.
- Batch processing uses sequential access for processing and the generations method for back-up.
- Transaction processing uses random access for processing and back-up requires regular snapshots of the files together with a transaction log.

## Questions

1 Data processing can be done in one of two ways. In transaction processing, data files are updated as transactions occur. In batch processing, the new data is collected together over a period of time and processed altogether in one batch. In a payroll system, the master file contains data about one employee and the transaction file contains data about the hours worked by the employee that week. One field will be common to both files. What is the field that is common and why is it needed?

2 Say which type of processing, transaction or batch, would be best suited to each of the following applications. Give a reason for each of your answers:

   a Holiday booking system in a travel agent.

   b Bar code system in a supermarket.

   c Producing gas bills.

   d Directory enquiry system.

   e Sending out statements to bank customers.

3 a What magnetic media can be used to store data that is required for random access processing?

   b What magnetic media can be used to store data for sequential access?

4 When electricity bills are sent out, batch processing is used to produce a set of bills from meter readings. In this application:

   a What data will be stored on the master file?

   b What data will make up the transaction file?

   c Why is batch processing an appropriate method for producing electricity bills?

5 When a customer comes to the electricity board showroom to pay a bill, their account details are accessed and updated there and then.

   a What method of processing is being used here?

   b Why is this type of processing appropriate in this case?

   c This type of processing is often called real-time. What does the term real-time mean?

6 A large company orders goods from a number of suppliers. Details about the suppliers are stored in a suppliers master file. One of the details kept is the total amount that has been paid to each supplier this year. When invoices arrive, asking for payment for goods received, a special form is filled in giving the supplier code number and the amount owed. Over the course of a week, a large number of forms will be collected. At the end of the week, the data from the forms is entered into the computer to form a payments file. The payments file is then processed against the suppliers master file and the system prints cheques that are then sent to the suppliers.

   a What name is given to this type of processing?

   b What is the key field in the suppliers master file?

   c Give two other fields, apart from this key field and total amount paid each year, that might be found in the suppliers master file.

   d What other name could be given to the payments file?

   e What process will need to be carried out on the payments file before it can be processed against the suppliers master file?

   f What else, apart from printed cheques, will be output from this system?

   g Draw a system flow chart to show the way in which data moves through the system.

7 A library has a file of books in which two of the fields are author and title. The librarian wants a list of all the books sorted alphabetically by author. For any particular author, the titles should be sorted alphabetically. In what order should the fields be sorted to produce the required list?

8 A school keeps records of pupils with surname, first name and date of birth as three of the fields stored. How should this file be sorted to produce a list of pupils sorted by date of birth? Note that pupils with the same date of birth should appear in order of surname. Pupils who have the same date of birth and surname should be listed in order of first name.

# 3 File security

## The need for security

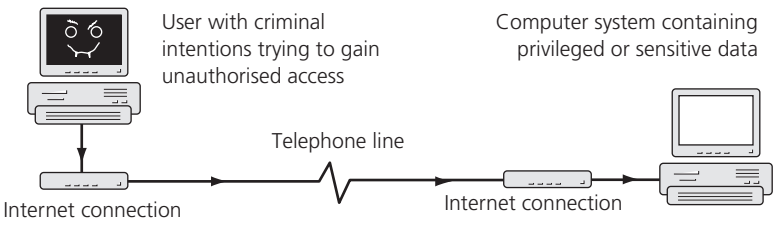
Most businesses are entirely dependent on the data that their computer systems store. If the data were lost then the business would not be able to function effectively and might even become bankrupt. If, for example, the customer file were lost then the business would be unable to send out goods or invoices to customers. Customers who had ordered goods would not receive them and those who had received goods would not get a bill.

If the data in a file is inaccurate then customers might receive the wrong goods or be billed for goods that they had not ordered. This is less serious than the total loss of all data, but it would cost the company goodwill and, if customers are not billed for goods they have received, then the company will lose money.

Much of the data that businesses store would be valuable to competitors. A business will therefore need to make sure that the data is not stolen and sold.

An organisation needs to protect its data from the following types of danger:

- Physical dangers:
  - Flood, earthquake and other natural disasters.
  - Fire.
  - Damage to magnetic media by heat, magnetic fields or water.
- Theft:
  - Theft of data including 'electronic' methods.
  - Theft of disks or tapes containing data.
  - Unauthorised copying of data, either at a workstation or by way of remote access (hacking).




*Computers connected to networks or the Internet are at risk from hacking*

- Processing dangers:
  - Accidental deletion of files or records.
  - Virus attack.
  - Incorrect data being entered and processed.

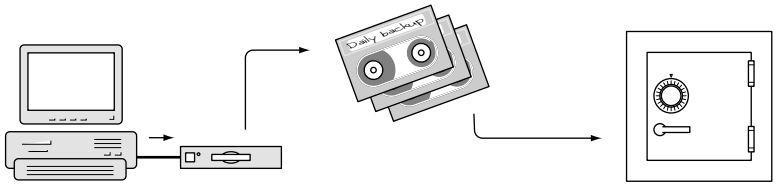
A number of different methods are used to protect data files from each of the above dangers or, if the data is lost, to ensure that the data files can be restored from back-up. These methods are described in this chapter.

## Back-up

The purpose of back-up is to make sure that if important files are lost or damaged then they can be restored from back-up. There are two methods of backing up data files. These are the use of generations of master and transaction file – used in batch processing systems – and the use of periodic copying

of files (file dump) together with keeping a transaction log – used in online or transaction processing systems. These methods are described in chapter 2.

For the back-up files to protect the system against loss by physical damage to the original, the back-up files must be kept safe from whatever physical risk there is to the working copy. This means that back-up files should not be stored near to the working copy and preferably they should be stored on a different site.




*Data is backed up onto tape and then put in a safe place*

If they must be stored on the same site, then they should be kept in a fireproof safe that will also protect against flood or water damage.

Data stored on portable magnetic media, such as floppy disk or tape cartridge, must not be left in direct sunlight and must be kept away from magnetic fields. Telephones and VDU units contain magnets that could damage the data stored on floppy disk or tape.

## Validation

Validation is a method of protecting against incorrect data being processed. Although validation checks cannot detect all incorrect data, they can be used to spot data that is obviously wrong. Validation can take place at any stage of processing, from input to output. Validation techniques are discussed in *GCSE ICT Theory Pack 1*, Chapter 7.

## Physical security

Physical security is used to prevent unauthorised access to the computer room or terminal. A number of methods are available. These include having security guards and passes, checking that each person entering the building or area which holds the computer is authorised to do so, etc. Special locks, activated by a swipe card or retina scan, can also be used. These electronic locks not only help prevent unauthorised access, they also monitor employees' movements as an additional security measure.

Offices containing computer terminals and also floppy disks or data tapes should be locked when left empty. The disks and tapes should be locked away when not in use, preferably in a fireproof safe.

Terminals should be logged off when not in use and a password system used to ensure that only authorised people can access the system.

## Electronic security

Access to the computer system should be controlled by the use of a hierarchical password system. Hierarchical means that there are different levels of user. Each user has a password that allows access to certain files or data. This will allow each employee to access the files and data that they need for their own work but no others. It can also restrict the type of access that the user has – one employee may need access to change data in a file (write access), while another needs only to view the data (read access).

Files that could be copied or those that could be stolen because they are on a portable medium like floppy disk, CD-ROM or data cartridge can be encrypted so that they are unreadable without a password. Encryption is also used when files are transmitted through a network, since it is very easy to intercept and copy them.

Encryption is a process that turns the data in a file into an apparently random jumble that will be useless to anyone intercepting it. The way that a particular letter is encrypted in a text file depends on the key or password used, but it also depends on other letters in the text. This means that a particular letter may be encrypted differently each time it occurs, making a properly encrypted file almost impossible to decipher. Encryption can be used to secure any type of computer file, and the file can only be restored to its original, unencrypted form using the original key or password.

## UPS and spike suppressers

If the electric power goes off while a disk drive is in the middle of writing data to the disk then the file can be corrupted. In the worst case, the data about where files are stored on the disk may be lost so that the whole disk becomes unreadable.

Similar effects can occur if there is a sudden change in the mains voltage. This can happen when another device is switched on or off.

Small computers and network servers can be protected against power loss by connecting them to an uninterruptable power supply (UPS). This device constantly monitors the mains power supply. If the power fails, it instantly switches to battery power. Most UPS devices come with software that can be run on the computer so that the UPS can communicate with the computer. If the power fails, the UPS passes a signal to the computer and the software shuts down the computer system in an ordered way.

A spike suppresser is a special plug that filters out any sudden changes, or spikes, in mains voltage, so that the computer receives a smooth power supply.

## Virus protection

A virus is a computer program. The virus program is designed to run when the computer is booted up, or else it is attached to another program and runs when that program is used. One feature of a virus is that it will copy itself many times both to the computer's hard disk and to any floppy disk that is used in the infected computer.

The virus will usually be undetected during this copying phase and then a particular action or event will trigger it. When a virus is triggered, it will probably display a message announcing its presence and it will also typically perform an action, which will destroy or corrupt the data stored on the hard drive.

Viruses are spread by running infected programs or by booting up the computer with an infected floppy disk inserted. Programs and files downloaded from the Internet can contain viruses, as can email.

Special anti-virus programs can be run to protect a computer from infection. These virus checker programs examine files and other programs to make sure that they are free of known viruses. If a virus is detected then the virus checker can automatically remove it and the affected files can sometimes be repaired.

Limiting the use of floppy disks and ensuring that only software from reputable suppliers is installed on the computer can provide additional protection against viruses. Pirated games and other software, passed from person to person, are common sources of virus infection.

## Key points

- Loss of data could result in a company going out of business.
- Data must be protected from accidental or deliberate loss or damage.
- Magnetic media can be damaged by fire, heat or stray magnetic fields and must be protected from exposure to them.
- Computer systems and their data need to be protected from unauthorised access and from exposure to natural disaster.
- If data is lost then a proper back-up strategy will allow files to be recreated from back-up copies, which should be kept in a safe location.

## Questions

1 Explain the term 'generations of back-up' and explain when this type of back-up system is appropriate.

2 In transaction processing, part of the back-up procedure is to copy the file regularly to a tape or to another disk.

   a Why is this, on its own, not sufficient to provide back-up?

   b What else is needed to provide back-up in a transaction processing system?

   c Describe how a file will be recreated from the back-up copy if the original is damaged.

3 Describe three ways in which a file could be lost or damaged.

4 What is encryption and how does it help provide file security?

# 4 The human–computer interface

## What is the human–computer interface?

The human–computer interface (HCI) is made up of hardware and software. Its purpose is to allow two-way communication between the computer system and the user. It is quite possible for a computer system to have several different HCIs. Each person – or even the same person – using each of the HCIs will have a different view of the computer system. Conversely, totally different computer systems would appear the same to users if they had the same HCI.

Sometimes an HCI will be very specialised. This would be the case in a graphic design system where the HCI would use high resolution VDUs together with a graphics digitiser and design software to present the user with an interface that would allow them to carry out all the usual tasks necessary in creating a design layout.

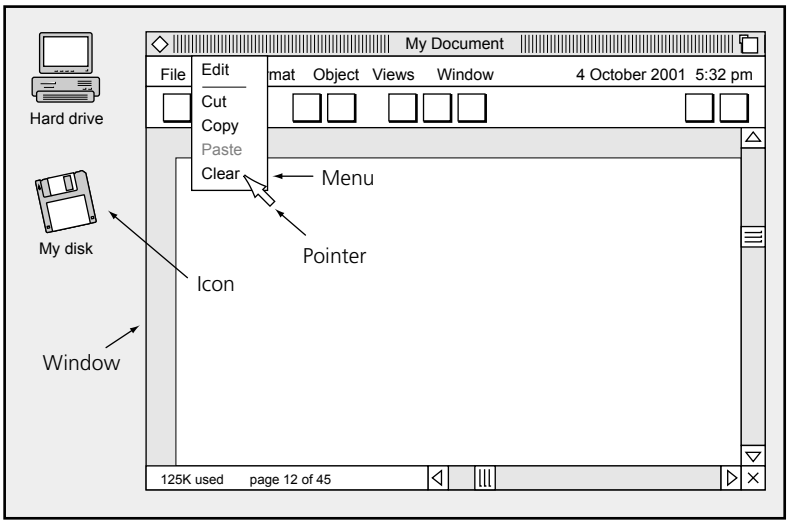
## Types of HCI

There are three different types of HCI: graphical user interface (GUI), menu and command line interface.

### Graphical user interface

The graphical user interface is the most familiar HCI. In this system, pictures or icons are used to represent files and programs.

Actions can be carried out by using a mouse to click on or manipulate the pictures. The icons and any open files are usually placed inside bordered areas of the screen called windows. Additional tasks can be carried out by using the mouse to click on a menu bar to pull down a selection of options. This type of system is often called a WIMP environment because it is made up of **w**indows, **i**cons, a **m**ouse and **p**ull-down menus.




The Windows operating system is a GUI WIMP human–computer interface. This type of interface is simple to use because complicated instructions are represented by related actions. Deleting a file, for example, can be carried out by dragging it to a 'recycle bin'. Recovering a file that has been accidentally deleted is done by opening the recycle bin, finding the file and dragging it out again. An interface like

this is sometimes called 'intuitive' because the user can guess how to instruct the computer to carry out certain actions.

Graphical interfaces are particularly suited for use by people who do not have a detailed knowledge of how computer systems work. They can also be used effectively by expert users because they allow tasks to be carried out simply and quickly. The only disadvantage of a graphical interface is that very complex tasks and sequences of instructions cannot be handled.

### Menu-based interfaces

A menu-based interface presents the user with a number of choices, each of which is labelled. The user instructs the computer which action to perform by pressing the key corresponding to the label. This type of interface can only be used in situations where there are a limited number of actions that can be carried out by the system.

In complex systems, there would be a series of menus. Each menu would display a group of related actions so that the user could easily find their way to the particular menu required. For example, there might be an edit menu, a print menu and a back-up menu.

Menu systems are useful where the operator has little or no computer knowledge and simply needs to select one of a series of operations to be performed.

### Command language

A command language allows the user to type in instructions for the computer to follow. The user needs to know the words that make up the command language and must also know how to use the words to instruct the computer.

Command languages can be used to build up sequences of instructions that make the computer carry out complex instructions. They can be difficult to use and any mistakes in an instruction could result in either the wrong thing being done or, less seriously, nothing at all happening.

Most user interfaces that are based on a command language expect the user to have a good degree of expertise. They offer little help or support if things go wrong. An example of a command language instruction is:

```
COPY C:\USERS\MYFILE.DOC A:\
```

This instruction would copy a document called Myfile from the USERS folder on the hard drive to a floppy disk. In a GUI interface, the same action would be carried out by double-clicking the USERS folder to open it and then dragging the icon representing the file to the floppy disk icon.

However, a command language could be used to copy all the files that have changed since last week from the folder to the floppy. This would be more difficult to do with the GUI.

The table on page 23 summarises the differences between interfaces.

| | Graphical user interface | Menu interface | Command line interface |
|---|---|---|---|
| **Hardware** | Keyboard<br>Mouse | Keyboard<br>Mouse<br>Touch-sensitive screen. | Keyboard |
| **Suitable for** | Inexperienced users.<br>Experienced users carrying out straightforward tasks. | Inexperienced user needing to carry out a limited number of tasks. | Experienced users. |
| **Used for** | Wide range of tasks. | Tasks where there are a limited number of known choices available. | System management tasks. |
| **Advantages** | Intuitive – can be used with very little training. | Simple to use.<br>All the available options are displayed. | Complex tasks can be performed. |

## Designing a human–computer interface

There are a number of considerations that must be kept in mind when designing a human–computer interface.

An interface should be consistent. This will help the user to apply experience gained in one part of the interface to another. An example of consistency for a menu-based interface would be to always place the 'Return to previous menu' option in the same place on each menu or to grey out menu options that are currently unavailable.

An important design consideration is how to provide meaningful error messages when things go wrong. Some interfaces provide an error message similar to 'Error 14509 has occurred'. This type of error message does not help the user identify what has gone wrong or what to do about it.

Most HCIs provide onscreen help so that the user can find out how to do something that they have forgotten or that they never knew. In GUIs, context-sensitive help is often a feature. The user can press a key to view a help screen that relates to the particular operation they are trying to carry out.

Use of colour is another important design consideration. Colours can be used to help the user. For example, using light grey for menu options that are unavailable. Colours are also important in making the interface pleasant to use. Bright or clashing colours will make the interface unpleasant to use or possibly even cause eyestrain. Colour combinations should be chosen so that the user has a pleasant and unintrusive combination of colours that provide a good contrast, for example, between the background and any text.

Sound should be used sparingly in an HCI. Constant sounds can irritate the user and distract others working in the same area. However, sound is a good way of alerting the user to a problem if an error occurs.

## Key points

- A human–computer interface allows the user to interact with the computer system.
- There are three different types of HCI – graphical, menu and command.
- Each type of interface is appropriate for different uses and for users with different levels of skill.
- The designer of an HCI will aim for consistency between the different parts of the interface.

## Questions

1 Name the three different types of user interface.

2 For each of the three types, give one advantage and one disadvantage.

3 a What type of interface is used for onscreen display control of television and video systems?

b Why is this type of interface particularly appropriate for this application?

4 What type of interface is used for Microsoft® Word?

5 A word processor and a spreadsheet are supplied by the same company. They have a consistent user interface.

a What is meant by a consistent user interface?

b Why is it an advantage?

c Give two examples of ways in which the user interface for the spreadsheet and word processor might be consistent.

# 5 Computer networks

A computer network is made up of two or more computers linked together so that they can exchange data and share resources. In addition, networks are often used as a means of communication.

Some advantages and disadvantages of networking computers are as follows:

- ✓ Expensive resources, such as a colour laser printer, can be shared.
- ✓ Software can be installed centrally for everyone to use (a network licence must be bought).
- ✓ Can be used for communication – email, personal time management, electronic diary and meeting scheduling.
- ✓ Data is stored centrally so everyone has access to the latest information.
- ✓ Work is available at any network station.
- ✗ The system is more vulnerable to unauthorised access (hacking) and virus attack.
- ✗ If the network goes down then no one can access their work.
- ✗ Access to data and software can be slow if the network is busy.
- ✗ You can only put computers in places where there is a network point or, for a wireless LAN, where there is a strong enough signal.

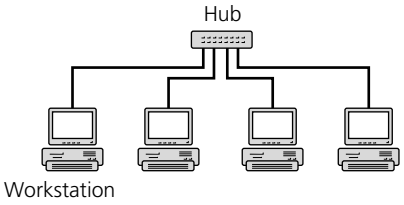
There are two types of network: local area networks (LANs) and wide area networks (WANs). These are described below.

## LAN networks

A LAN connects computers in a single room, building or site. The computers are likely to be PCs with, perhaps, a mini-computer as well. The data is transmitted directly in binary form through the cable that joins the computers together. Radio connections may replace the cables to provide a wireless LAN.

Most LANs have a special computer called a file server. This computer has one or more large hard drives that all the computers on the network can access. Users may be allocated space on the file server hard drive so that they can access their work from any computer on the network. Software can either be installed on the individual workstation or centrally on the server. This type of network may also have a printer server that handles printing. Printout is not sent directly to the printer. The workstation sends the data for printing to the file server which stores the print job on its hard disk. A number of different print jobs from one or more workstations may be stored at any one time. These form a print queue. The process of storing print jobs is called spooling. The printer server takes each print job in turn and prints it out. This process is called despooling.

Some LAN networks do not have a file server, but simply link computers together. One way of doing this is to connect each computer to a device called a hub. One computer may be able to access data stored on any other computer's hard drive. This type of LAN network is called a peer-to-peer network.



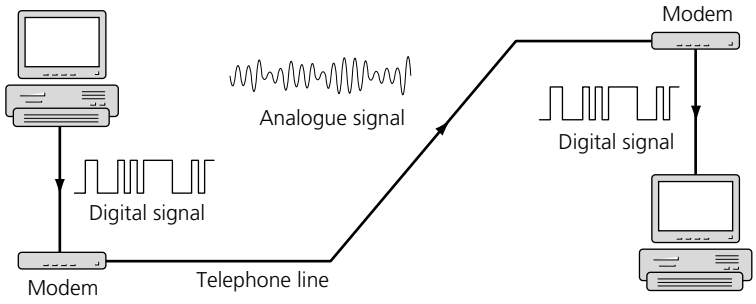

*Peer-to-peer network utilising a hub*

## WANs, modems and ISDN

A WAN connects computers over a wider area than a LAN. WANs join computers in different cities, countries or even continents. Although small desktop computers will connect to a WAN, there is likely to be one or more mainframe computers also connected.

Most WANs use a telephone cable to connect the distant points of the network together. This causes a problem since electrical pulses that are used to transmit binary data along a LAN cable will not travel down a long wire.

If a WAN is connected using ordinary telephone wires then a modem must be used to convert the computer digital pulse signals into a modulated signal that can travel along a long wire. At the other end of the wire, the signal must be demodulated, ie turned back into the binary pulses that the computer understands.




For personal computers, a modem may be internal (fitted inside the case) or external (plugged onto the back of the case). Large computer systems would have a number of modems allowing many different connections (one for each user) to be made at the same time. These would be external and mounted in a special cabinet inside the computer room.

ISDN (integrated services digital network) lines provide a faster alternative to using a modem and an ordinary telephone line. Data can be transmitted in digital format using an ISDN line so a modem is not needed to modulate the digital signals from the computer. ISDN connections are available in several forms. The simplest form consists of two channels each able to transmit data at 64 000 bits per second. Working together, the channels can transmit data at 128 kbps, which is many times faster than the best telephone plus modem connection of 48 kbps.

An ISDN line can also be used for voice. In fact, one of the two channels can handle a telephone conversation while the other is handling data passing to and from a computer. However, since ISDN transmits digital data and the telephone signal is analogue, a modem is needed to connect the telephone to the ISDN line. The modem converts the analogue voice signal to the digital format needed for transmission along the ISDN line.

A special line must be brought to the ISDN connection point. A computer cannot handle data in the format that the ISDN line transmits it, so the computer cannot be plugged directly into the ISDN socket. A terminal adapter is used to connect the computer to the ISDN socket. Note that the terminal adapter is not a modem. It is not modulating the computer data, which remains in digital format. If an ISDN connection is used then the computer at the other end must also be connected via an ISDN line. Many Internet service providers now have ISDN connection facilities.

One additional advantage of ISDN connection is that devices like routers can be connected directly to them. A router is a network device which is responsible for passing network data to the right computer.

Connecting a network router to an ISDN point allows all the computers on the network to access the ISDN line. This is a way of providing a number of computers access to the Internet without the expense of supplying each with its own telephone line and modem.

The disadvantage of ISDN is that the service is more expensive than an ordinary telephone line, both to install and for quarterly charges. It becomes cost-effective if the ISDN connection is to be used by a number of computers or if large amounts of data are to be transferred.

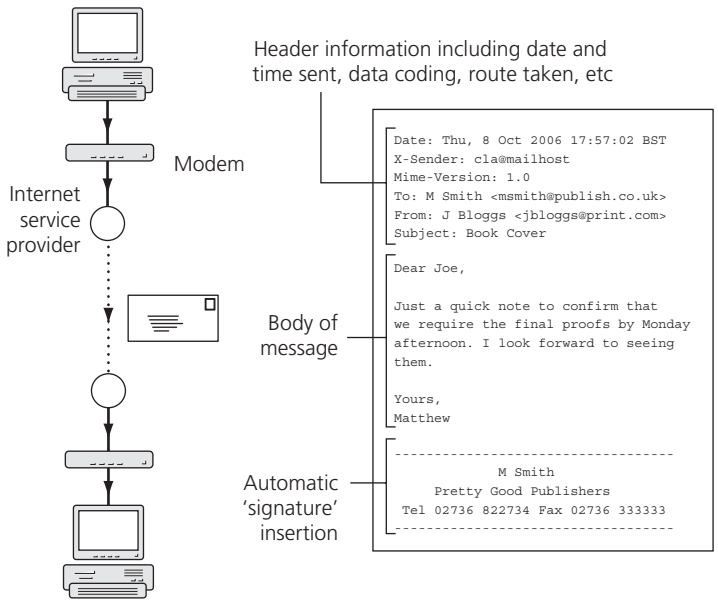
| LAN | WAN |
|---|---|
| Connect computers in a single room, building or site. | Connect computers in different towns, countries or continents. |
| Involve mainly PCs, possibly with a mini-computer. | Connect mainframe computers, mini-computers, PCs and terminals. |
| May involve a file server, printer server and terminators. | Will need a modem if wire rather than fibre-optic cable is used. |
| Signals sent directly as binary pulses (1s and 0s). | Signal modulated (high pitch/low pitch) for transmission through wire cable. |
| Limited length unless special repeaters are installed. | No length restriction. |

*LANs and WANs compared*

## Email

One obvious type of communication that can take place over a network is electronic mail (email).

Email is a system that allows someone to type out a text message on their computer. The message is addressed to another person and, when completed, it is sent (uploaded) to a central computer. When the recipient logs on, they can copy or download the email to their own computer, where it can be read or printed.




This type of communication has several advantages over other forms such as telephone, letter or fax. Email is sent to the central computer, not to a specific address. It can be read by the person logging onto any network computer. It is also possible to attach other files to the basic message, so word-processed documents, picture files, in fact, any type of file at all can be sent. Large files are often compressed before being sent with email.

Some email systems will automatically generate and send an email back to the writer giving the time that the recipient read the mail.

Email is easier to answer than ordinary mail. All that the recipient has to do is click the reply button and type in their response to the mail; the return address is automatically filled in by the software. They then click the send button and the mail will be uploaded next time they connect to the mail server.

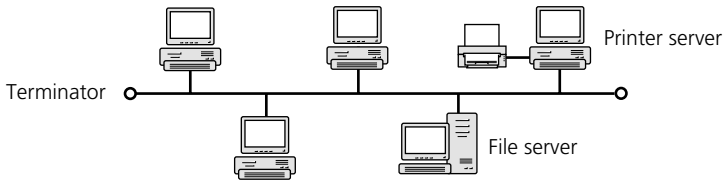
The table on page 29 compares email with letter, telephone and fax as a means of communication.

## Network geometry

There are a number of different ways in which computers can be arranged on a network. Two different ways, a bus network and a mesh network are described below.

### Bus network

A bus network consists of a single network cable. Network stations, a file server and printer servers are connected to the cable and terminators are placed at each end.




*Bus network*

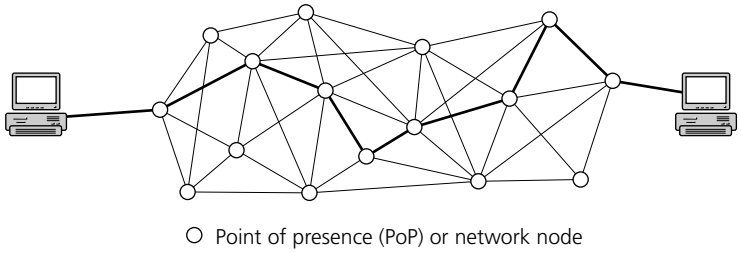
This arrangement is used for LAN networks and the cable carries electrical pulses representing 0s and 1s. The terminators stop these electrical pulses reflecting back along the network cable.

### Mesh network

A mesh network geometry is used for WAN networks. The computers that form the network are connected together directly so that there are several different paths from one computer to another.

Data is transmitted through this type of network by a process called packet switching. The data is split up into a number of packets. Each packet has additional data added to it which identifies the source and destination address. The packet also has a sequence number added to its data. The packets are then sent individually through the network by any available route. Some packets will take one route and others a different one. They are passed from point to point through the network until they arrive at their destination.

When the packets are received at their destination, the sequence number is used to reassemble them in order so that the data can be extracted. Packet switching allows the network load to be spread more evenly than making a direct connection and sending all the data along it.




*Packet switching*

| Email | Letter | Telephone | Fax |
|---|---|---|---|
| Communication sent to a central computer that can be accessed from anywhere. | Communication sent to a physical location. | Communication to a physical location. | Communication to a physical location. |
| Recipient does not need to be available when the communication is sent and can read it from almost anywhere in the world. | Recipient does not need to be available when the letter is posted but must be at the address the letter was sent to if they are to open and read it. | Recipient needs to be present while the communication is in progress. | Recipient does not need to be available when the communication is sent but must be there to read it. |
| Fast – usually available for reading within minutes of sending. | Usually takes one or more days. | Fast – immediate communication if the other person is available. | Fast – available for reading as soon as it is sent. |
| Private – can only be read by the intended recipient (password needed to log on/read mail). | Private as long as mail is secure when received. | Private – can only be heard by intended recipient. | Not private. A fax left on a fax machine can be read by anyone. |
| Recipient has to collect the email by logging on and downloading. | Delivered to the recipient – no need for any special action. | The recipient is there to collect the message – does not need to do anything apart from answer the phone. | Recipient does not need to do anything to receive the fax. |
| Most mailing systems allow a single email to be addressed to many different locations – so one email can be sent to multiple destinations at no extra cost. | One letter goes to one address. | One phone call goes to one recipient. | One fax goes to one fax machine. |
| Not interactive | Not interactive | Interactive | Not interactive |
| Recipient must have an email facility and computer hardware and software. Not everyone has these. | Everyone has an address. | Most people have a telephone. | Many companies and some individuals have fax machines. |
| Copies of computer files can be sent. | A physical document is sent. This may be necessary on, for example, legal documents where a signature is needed. | Only spoken information can be exchanged. | Copies of diagrams and documents can be sent but the quality may be poor because of low resolution. |
| Low cost per message sent – many emails can be sent all over the world very cheaply. | Fairly high cost per message – cost increases sharply with size (weight) of message and if the address is outside the country in which it is sent. | Cost increases sharply with distance and with length (duration) of message. | Fairly low cost per message, but cost increases with distance because of the way that telephone charges are structured. |

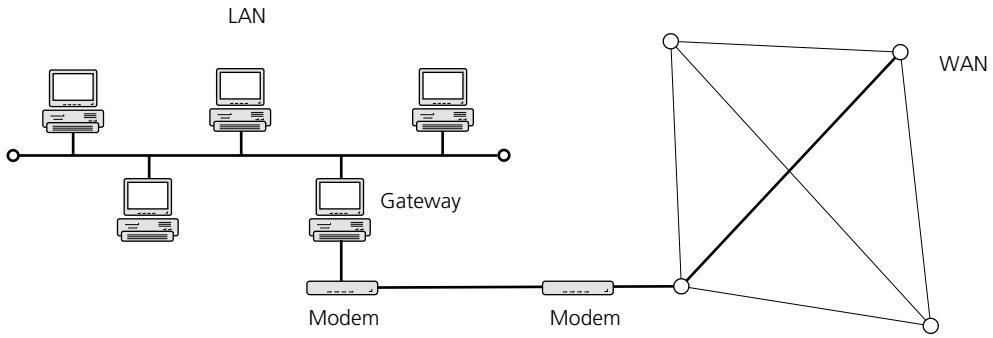
*Comparing different methods of communication*

Since a mesh network is used for WANs, the network links will extend over hundreds or even thousands of kilometres. The links may be wire or fibre-optic cable and they may involve radio signals and satellites. If wire is used then the signals will have to be modulated and so each connection will need a modem.

A mainframe or mini-computer can handle several network links at any one time. In this case, there will be a modem for each of the possible links.

## Gateways

A gateway is a computer that links two different types of network. For example, a gateway could connect a LAN to a WAN. There would be one connection from the LAN to the WAN via the gateway. Any computer on the LAN would then have access to the WAN. If another LAN were also connected to the WAN, then a computer on one LAN could communicate directly with any computer on the other LAN.




*Gateway connecting a LAN and a WAN*

## The Internet

The Internet is made up of a large number of networks all connected together. Internet providers own computers that are part of the Internet. People pay a provider to link their home computer to the provider's computer using a modem and telephone line. This gives them access to the Internet. The computer that they link to is called their point of access. The user pays a monthly fee and there are telephone call charges (at the local rate) while they are actually connected to their point of access.

In addition to a point of access, the user also normally gets some or all of the following:

- Software to handle connecting and logging on, together with a browser to allow them to view pages of information available on the Internet.
- One or more email addresses to allow them to receive emails.
- Software to allow them to compose and send emails.
- Space on the supplier's computer to store their own Web pages.

Once connected to the Internet, the user will be able to:

- send and receive emails
- search for and display information on almost any topic
- order and buy a wide variety of goods

- obtain technical help, particularly for computer equipment and software from a number of specialist sites, many of which are supported or maintained by leading manufacturers
- download free software, including the latest drivers for hardware and upgrades for software
- engage in real-time 'chat' sessions in a variety of forums dedicated to specialist topics.

## Web pages and browsers

The Internet is made up of many different types of files stored on Web server computers all around the world. One particularly important type of file is a special text file called a hypertext mark-up language (HTML) file. This type of file uses a special language to describe the layout of a Web page. Browser software can interpret the HTML language to display the Web page graphically on the user's computer.

One important feature of a Web page is that it can contain hyperlinks. Hyperlinks point to other Web pages and, when a hyperlink is clicked, the browser will find and load the Web page that it points to. This allows the user to navigate the Internet by clicking on hyperlinks. A given Web page usually contains hyperlinks to other pages on the same site and many list links to other related sites as well.

If the browser follows a hyperlink to a file that is not another Web page, an executable program file, for example, the browser software will offer the user the choice of downloading the file (ie copying from the Web server computer to their own computer).

Browser software also allows the user to bookmark particular sites so that they can be found again easily. It keeps a list of sites (history) that have been visited over the past days or weeks, again to allow the user to find a useful site again.

If the user knows the address (URL or uniform resource locator) of a Web page then this can be entered directly and the browser will locate and load in the page. A typical URL address is http://www.pearsonpublishing.co.uk/, which is the address of Pearson Publishing.

Although HTML files are text-based, they can include embedded graphics and sound. They can also include special small programs called applets which will download and run on the user's computer, enhancing the facilities offered by the browser software. An example of an applet would be software to allow the user to rotate an image. This might be used by a shopping site to allow customers to view an item from different angles. Applets are written in a special language called Java that can run on any type of computer.

## Search engines

The Internet contains so many Web pages that it is impossible to catalogue them all. Even if a catalogue were produced, it would immediately be out of date, since pages are continually added, deleted and amended.

Search engines are the Internet's answer to finding information. A search engine site keeps track of a large number of Web pages. Basically, it scans each page that it is keeping track of and builds up a list of significant words that appear on that page.

When someone searching the Internet for information uses the search engine, they enter one or more key words. The search engine then produces a list of pages where the user's key words and the words on the page match. The list is presented as a series of hyperlinks that the user can click to go directly to the page.

In fact, most searches produce lists of hundreds or even thousands of matches. Search engines allow more advanced searches using AND, OR and NOT (just like database searches) to produce more useful lists of matches.

## e-commerce

The Internet is increasingly being used to buy and sell all sorts of goods and services. Some e-commerce takes place entirely on the Internet. An example of this would be buying a computer program where, having supplied a credit card number, the customer can download the software straightaway.

Many supermarkets provide Web sites where customers can fill a virtual shopping trolley. The order is then either delivered or put together in the shop for the customer to collect.

A wide variety of stores have virtual shop fronts, allowing customers to order and pay for goods that are then delivered by post or carrier. Books, music CDs and computer components are examples of this. In some cases, for example, http://www.amazon.com/, the business has been specifically set up to trade over the Internet.

Large companies sell on the Internet because they do not want to lose out to their competition, but, for a small business, selling over the Internet has particular advantages since their potential market is expanded to include the whole world. This can be a tremendous benefit to a business dealing in a highly specialised or niche market where customers will actively seek them out and where there is little competition.

Another development in the e-commerce world has been the creation of Internet auction sites, where goods are offered and bids made over a period of several days.

One concern over the development of e-commerce has been over the security of transmitting credit card and personal data. This has led to the development of secure sites, which guarantee secure transmission of data by using encryption techniques. Secure sites often have a URL that starts with https instead of http. Browser software will indicate that a site is secure, typically by showing a locked padlock icon on the screen.

The Internet can also be used to book flights, train tickets, hotel accommodation, theatre seats and so on. E-commerce gives the customer a wider choice of where to buy goods and allows prices to be easily compared. The supplier does not need to maintain expensive shop premises and can have a worldwide customer base. The disadvantages for the customer are the possibility of fraud, the need to pay import duty and the lack of consumer protection when goods are supplied from overseas.

## Global ICT services

Using the Internet as a method of communication allows service providers to supply customers who may be on the other side of the world. One example of this is the service of designing and providing Web sites for businesses. Producing multimedia presentations is another area where supplier and customer may well be in different countries or even continents.

Provision of global services allows a company to contract out specialised parts of a job to an expert without having to pay travel and accommodation expenses. A Web-page designer may need to produce an Applet program as part of a Web page that they are working on. This task could be contracted out to a specialist somewhere else in the world.

## TV, the Internet and mobile computing

Digital television providers are now integrating Internet access into their services. A Web page can be transmitted to and displayed by a television screen. The television set can then be used for Internet access rather than the family having to buy a computer.

A telephone link is still needed in the case of terrestrial and satellite services. This carries data from the home back to the provider (uploading). Data is downloaded alongside the normal TV broadcast. This provides a faster service than a computer and modem. Cable providers have the potential to provide a two-way communication channel through their fibre-optic cable.

Limited Internet access is available on special WAP (wireless application protocol) mobile telephones. Many ordinary mobile telephones can be used to link laptop computers to the Internet using the laptop's infra-red communication port.

## Key points

- Computers can be linked together to form a network.
- Networked computers can share data and other resources such as printers.
- Networks are also an important method of communication.
- Networks may be slow at busy times and it may be impossible to work if there is a network fault.
- There are two types of network – local area networks (LANs) and wide area networks (WANs).
- Connection can be via an ordinary telephone line or via an ISDN line.
- Email is an important method of communication. It has advantages and disadvantages compared to the more traditional methods of letter, telephone and fax.
- A bus network may be used to connect computers on a LAN and a mesh network for computers on a WAN.
- A mesh network is likely to use packet switching to transmit data.
- The Internet is a worldwide linking of networks. It provides information and opportunities for commerce including online booking systems, sales and auctions.
- A search engine can be used to find Web sites relating to particular key words.

## Questions

1 What is a computer network?

2 What are the differences between a LAN and a WAN?

3 Give two advantages and two disadvantages of using a LAN rather than stand-alone machines in a school.

4 a John does not have a computer but he would like to be able to send electronic mail to his friends. What hardware and software will John need to buy?

b What advantages will he gain in sending electronic mail rather than ordinary mail?

5 Information can be sent from one place to another using email, fax, telephone or normal post. Choose the best method for each of the following situations and explain your choice clearly:

   a Sending an urgent order to a company.

   b A business sending updated price lists to all its travelling salespeople who are moving from hotel to hotel throughout the country.

   c Inviting people to a wedding.

   d Contacting a friend who has had an accident to find out how she is getting on.

   e Sending a signed contract to a company.

6 Some of your choices in responding to Question 5 will have been for electronic mail or fax. Why might you decide not to use either of these methods even though it is the best?

# 6 Data logging

In Chapter 8 of *GCSE ICT Theory Pack 1* and Chapter 1 in this pack, we looked at capturing data either from forms or from computer-readable documents using OMR, OCR, MICR and so on. Data captured like this typically results from commercial and financial transactions and operations.

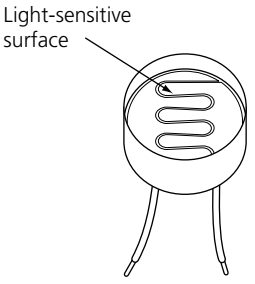
Data is also generated in scientific experiments and in other situations where physical quantities such as temperature or speed are being recorded. This data can be collected, stored and processed by a computer system just like any other data. When the data is collected automatically, the process is called data logging.

A data-logging system will use sensors as input devices. These allow the system to measure physical quantities and to detect events.

## Sensors

A variety of sensors is available to allow measurement and detection of a wide range of physical quantities and events:

- **Switch** – There are a number of different switches that can be used to detect a variety of events. A pressure switch can be placed under the carpet on a stair tread to detect when someone stands on the stair. This could be used in a burglar alarm system. An infra-red source and detector can act like a switch, detecting when the beam is broken. This could be used to detect and measure the movement of small animals along a woodland path. A magnet and magnetic reed switch can be used in a door as part of a burglar alarm system.
- **Thermistor** – A device whose electrical properties change with temperature. It can therefore be used as a temperature sensor. It needs to be calibrated before it can be used by measuring its output at two known temperatures. Once the thermistor reading is known for two temperatures, it is possible to work out what the temperature is for other thermistor readings.
- **Strain gauge** – A strain gauge's electrical properties change as the gauge is stretched and compressed. It can be used to measure what is happening to a girder or other parts of a structure as a load is applied.
- **Light sensor** – A light sensor's electrical properties change according to the amount of light falling on it. This type of sensor is often called a light-dependent resistor (LDR). A light sensor can be calibrated to give a measurement of how bright the light is. It is, however, often used as a switch when it is calibrated to give only two readings so that it detects the presence or absence of light. A light sensor can be used to turn lights on when it is dark.




*Light-dependent resistor*

- **Movement sensor** – A movement sensor works by detecting the changes in a beam reflecting off a moving object. These sensors are used in burglar alarm systems to turn external lights on and off automatically. The sensor would be calibrated according to where it was positioned and what it had to detect. An external sensor would be calibrated to detect people, while not reacting to small animals such as cats and dogs.

## Advantages of data logging

Data logging has a number of advantages over manual methods of recording data. These are outlined below:

- When data has to be collected over a long time period, it is more convenient to have the data collected automatically by a data-logging system. An example of this would be collecting data about the weather. For example, the air temperature measured twice a day each day for a year.
- When data changes very quickly it would be impossible to take readings manually. For example, measuring pressure during an explosion.
- Computer readings are less likely to be wrong (as long as the sensors have been properly calibrated). There is no opportunity for human error.
- The data can be stored for later processing.
- The data can be processed and the resulting information presented in useful formats such as graphs and charts.
- Data from the sensor can be transmitted to a distant point. This allows measurements to be taken in places that would otherwise be inaccessible or dangerous.

## Accuracy and sensitivity

Data logging is often used because the readings are more accurate than those taken by a human, particularly if the data is changing quickly. The accuracy of the reading depends on how sensitive the sensor is and how well it has been calibrated. The sensitivity decides the smallest change that the sensor can detect.

Perfectly accurate readings can, however, be misleading if the time interval or frequency of sampling is wrong. The frequency of sampling refers to how often readings are taken and the time interval is the time between readings.

If the time interval is too long then the system will not record important intermediate values. Think of a Physics experiment where the temperature of a beaker of water is being measured as it cools from boiling point to room temperature. The purpose of the experiment is to draw a graph showing the pattern of cooling. If the time interval chosen were 30 minutes, then we would get very little information from the data collected, since the water would have cooled between the first and second reading.

If a time interval of five seconds were chosen, then we would have a great many readings with little difference between one and the next. These readings would take up more storage space than necessary and they would take more processing than if a more sensible time interval were chosen.

A reasonable time interval in this situation would be two minutes. This would provide enough readings to show the pattern of cooling without producing so many that storage space and processing time were wasted.

## Control systems

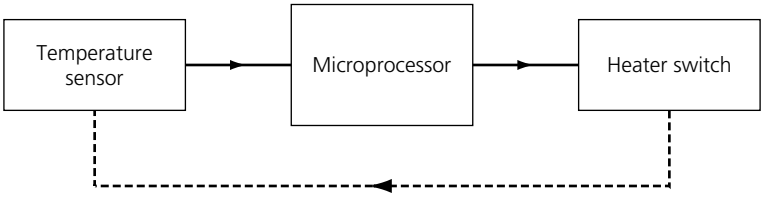
Sensors are also used in control systems where the output from the computer is used to perform some action. Control systems tend to be based on microprocessor chips because they are small, robust and fairly cheap.

The control unit of the central heating system in a house, for example, has two sensors. One is the room thermostat, which indicates if the main room in the house is too hot or too cold. The other sensor reads the temperature of the water flowing back into the boiler.

If the room is too cold and the water is hot enough, then the control unit outputs a signal to open the valve so that water goes to the radiators, otherwise the valve is shut to stop hot water going to the radiators. If the water is too cold, then the control unit will turn the boiler on, and if it is too hot, then it will turn the boiler off. The control unit constantly processes data to maintain the hot water and the room temperatures.

The system is further complicated because the control unit can be programmed to turn the water and/or the room heating on and off several times each day.

The diagram below shows a simpler control system that maintains the correct temperature in a greenhouse:




*Greenhouse control system*

The microprocessor system has a small program stored in ROM. The program regularly samples the temperature in the greenhouse. If the temperature is too low, the heater is turned on. If the temperature is too high, the heater is turned off. This cycle continues as long as the control system is running.

This system, like many control systems, involves feedback. Feedback is when the output from the system affects subsequent input. Turning the heater on or off (output from the greenhouse system) affects later temperature readings (subsequent input).

The effect of the feedback in this system is to move the temperature constantly towards an optimum value. When the temperature is too low, the output causes the temperature to rise towards the optimum. When the temperature is too high, the output causes it to fall towards the optimum. The effect is that the temperature actually oscillates above and below the required temperature, always moving towards it, overshooting and then moving back, but never moving too far from the required value.

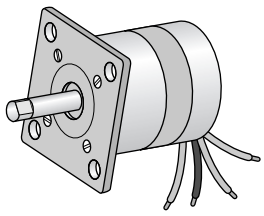
Feedback is also employed in other computer systems. A supermarket stock control system produces output (orders for new stock) that attempts to keep the stock levels in the shop at an optimum value.

## Output devices

There are a number of specialised output devices used in control systems. Two common ones are the relay switch and the stepper motor.

A relay switch allows a low voltage, small electric current to switch a larger voltage or high current device on or off safely. It is used wherever a computer control system has to switch a mains device on or off.

A stepper motor is a very specialised motor in that the angle the shaft of the motor turns through can be controlled by output from a computer system. The motor can therefore be made to turn through a precise angle under the computer's direct control. Stepper motors are used in printers to move the print mechanism precisely back and forwards.



*Stepper motor*

## Key points

- Computer systems can collect measurement data in a process called data logging.
- Data logging requires sensors for input devices. Sensors may need to be calibrated before they can provide accurate measurements.
- Data logging allows measurements to be taken over long or short time intervals and over long or short distances.
- Measurement data can be stored for later processing.

## Questions

1 For each of the following computer control applications say which device would be most useful and whether it is an input or an output device:

   a Detecting when the water in a washing machine is hot enough.

   b Turning emergency lighting on.

   c Moving the pen on a graph plotter.

   d Detecting when it has got dark.

   e Warning that something has gone wrong.

2 List three input devices and one output device that might be used in a burglar alarm. Explain the purpose of each.

3 Apart from burglar alarms, other computer control systems can be found in the home. These systems make use of microprocessors rather than the larger processors that are used in mainframe computers.

   a Give two reasons why microprocessors are used in most control applications.

   b Identify one household item that uses a microprocessor-based control system.

   c Identify the input and output devices used by this item.

   d Many control systems store programs and data on a ROM memory chip. Why is this more suitable for this type of application than using RAM or disk backing storage?

4 A biologist wants to record how many small animals pass down a track each night. The measuring equipment is to be left in place for one week. At the end of the week, the biologist wants to know the number of animals passing a particular point during the night.

   a What sensors would be appropriate for this system?

   b What storage device would be used to hold the data as it was recorded?

   c What advantages are there in using a computer-based system to log the data rather than observing directly?

   d What disadvantage is there in using a computer-based system?

5 A temperature sensor is used with a data-logging computer system to record the way in which a beaker of boiling water cools.

   a What would be a suitable time interval for readings?

   b Give two possible ways in which the data recorded during the experiment might be displayed. What are the advantages and disadvantages of each way of displaying the data?

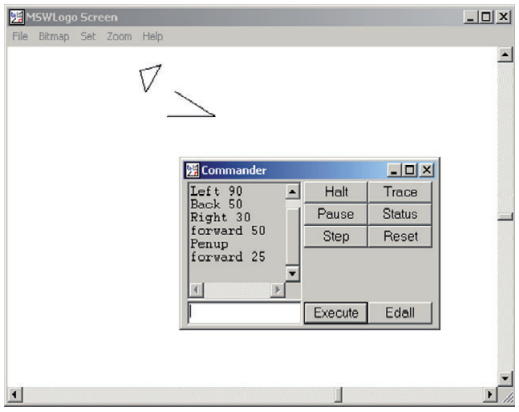
# 7 Computer languages

A computer language is a system of words or commands that give the computer instructions. A set of these commands that instructs a computer to carry out a particular task is called a program. There are many different computer languages, but here we will look at one called LOGO.

LOGO can be used to program quite complex applications. However, because it was developed to help teach computer programming, it has a simple, user-friendly interface.

LOGO allows the user to draw lines on the computer screen. The lines are drawn by instructing the computer to move an arrow on the screen. The arrow is called a turtle, because sometimes LOGO is used to make the computer move a real device, which is also called a turtle. As the turtle moves, it draws lines.

The screenshot on the right shows three lines drawn by the turtle, which is represented by a triangle. The instructions that have been used to draw the lines are shown in the Commander window. The last two instructions in the list have told the turtle to stop drawing (Penup) and move forward 25 units.




There are many different versions of LOGO. The version used in the screenshots in this text is MSWLogo, which is available as a free download from www.softronix.com.

## Some LOGO commands

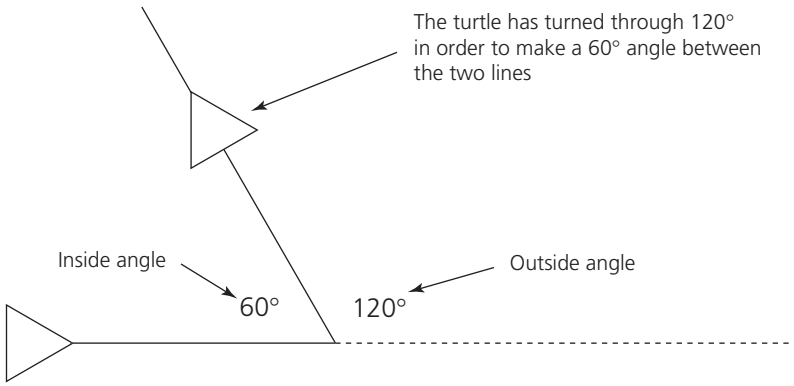
LOGO contains many different commands. Eight are given below:

| Command | What it does |
|---|---|
| Forward | Moves the turtle forward a given distance. For example, the command 'Forward 100' makes the turtle move forward 100 units. |
| Back | Moves the turtle back a given distance. For example, the command 'Back 20' makes the turtle move back 20 units. |
| Left | Turns the turtle left through a given angle. For example, the command 'Left 90' makes the turtle turn left through 90°. |
| Right | Turns the turtle right through a given angle. For example, the command 'Right 30' makes the turtle turn right though 30°. |
| Penup | This instruction stops the turtle drawing. It can still move about on the screen, but it does not draw a line as it moves. |
| Pendown | This starts the turtle drawing again after it has been stopped by a Penup instruction. |
| Home | Moves the turtle back to its home position, which is pointing upwards at the centre of the screen. |
| Clearscreen | Clears any lines that have been drawn and takes the turtle back to the home position. |

## The turning angle

If you want to make the turtle draw two lines that have a particular angle between them, it is easy to mistake the angle you need to turn the turtle through. If you draw a diagram then it is often easier to work out the correct angle.

The diagram below shows that, to draw two lines with 60° between them, you must make the turtle turn through 120°. This is because the angles on a straight line add up to 180°. It is important to realise that the turtle must turn through the **outside angle**, not the inside angle.




## LOGO loops

To draw a regular hexagon (six-sided figure) with a side of 50 units and an inside angle of 120°, we would need twelve turtle instructions. They would start off like this, with the same movement and turn repeated six times:

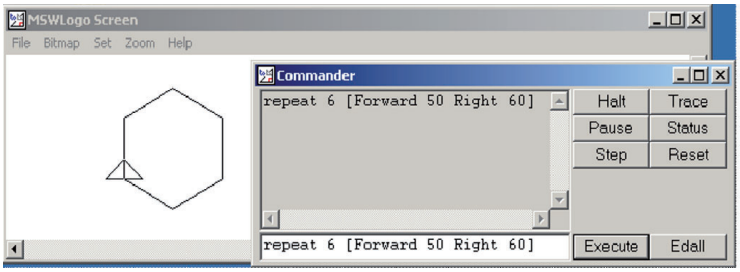
Forward 50
Right 60
Forward 50
Right 60
Forward 50
Right 60
etc

This would be quite time-consuming to type in, so LOGO has a way of telling the turtle to repeat something without having to type it out over and over again. This is the repeat loop.

The loop that would draw a regular hexagon is:

repeat 6 [Forward 50 Right 60]

Notice how the loop instruction is built up. It starts with the word repeat. Next comes the number of times that instructions must be repeated. Finally, in square brackets, are the instructions that will be repeated. You can put as many instructions as you like inside the square brackets. The screenshot on the next page shows the loop being used to draw a hexagon in MSWLogo.




## Procedures

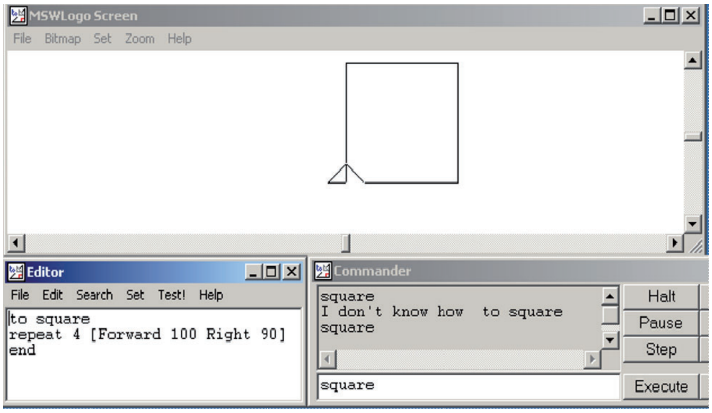
When writing computer programs, we often need to use a group of instructions several times. In LOGO, you can save a group of instructions and give them a name. When you want the turtle to follow the set of instructions, you just use the name you have chosen, as though it was a standard LOGO command. A set of saved instructions like this is called a procedure.

One advantage of using procedures is that you only have to write out the instructions once. Then, every time you want the turtle to follow these instructions, you tell it to do the procedure by using the name you gave to the procedure when you saved it.

Another advantage is that, if there is a mistake in the instructions, you can go back and change the procedure. You do not have to write out all the instructions again.

LOGO procedures start with the word To. The name of the procedure comes after the To. You have to make up a name for a procedure and it is best to choose a name that will help you remember what the procedure is for. The last line of the procedure must be the word End.

The screenshot below shows LOGO's response both before and after a procedure called 'square' was typed in. Before the procedure was defined, LOGO reported an error when the command 'square' was entered (in the Commander box). After the procedure was entered (in the Editor box), LOGO accepted the new command and followed the instructions which used a loop (with Repeat) to draw a square.

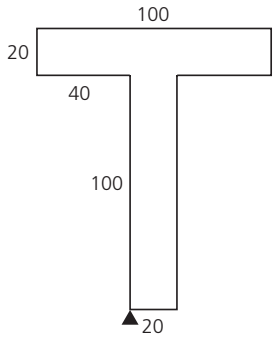


## Key points

- A computer language is made up of special words that can be used to give a computer instructions.
- A set of instructions, written in a computer language, that instruct the computer to carry out a particular task, is called a program.
- A computer can be programmed to control one or more devices.
- If we need to program the computer to repeat the same set of instructions a number of times, then a loop can be used.
- A procedure is a section of a program that is given a name and saved. The procedure name can then be used each time we want that set of instructions to be carried out.

## Questions

1 If the turtle starts out pointing vertically upwards in the bottom left-hand corner, what instructions would draw the shape below? In your answer, use only the following LOGO instructions: Forward 100, Forward 40, Forward 20, Left 90, Right 90.




2 What instructions would be needed to draw a regular ten-sided figure (decagon) with each side 30 units long? The internal angle of a decagon is 144°.

# 8 The system life cycle

## Developing ICT systems

Computer systems are developed in a number of stages that make up the system life cycle. The process is called a cycle because it repeats. Once the system has been put in place and evaluated, it will need fine-tuning. This will result in changes to the system being developed and so the process will repeat.

The stages involved in the system life cycle are:

- **Analysis** – the existing system is observed, problems identified and a clear idea of the problem to be solved developed.
- **Design** – the new system is planned.
- **Implementation** – the new system is created.
- **Testing** – the new system is tested to make sure it performs as expected.
- **Changeover** – the working system is put in place and used.
- **Evaluation** – the new system is measured against the original performance criteria to see how well it performs.

## Analysis

The purpose of analysis is to identify the problem that is to be solved and to reach agreement on what the solution will involve.

The first stage in analysis is to make sure that there really is a problem and that an ICT solution is an appropriate way of tackling it.

A systems analyst investigates what problems are being experienced in the current system and what possible solutions exist. This initial investigation is called a feasibility study and it results in the production of a feasibility report. This report gives a clear statement of what the problem is and it outlines possible solutions. Finally, the feasibility report identifies the most cost-effective solution and recommends it as the one to be adopted.

If the feasibility study recommends an ICT solution then a detailed analysis is done. This identifies what outputs the system must produce, what inputs and processing must take place to produce these outputs, and what data must be stored.

A systems analyst carries out this detailed analysis of the system. The analyst uses a variety of methods to identify how the system works. These methods include:

- **Observation** – observing the existing system, ie following documents through the system or shadowing people working in it.
- **Interview** – questioning the people who work within the system.
- **Questionnaire** – using a questionnaire when there are too many people to interview.
- **Collecting forms** – collecting documents that are used within the system. Not only because the same type of form must be output by the new system but also because documents used within the system will help identify what outputs, inputs and data are present.

Towards the end of the analysis stage, once the systems analyst is clear as to the purpose and requirements of the system, a set of performance criteria are agreed. The performance criteria are used during the design phase to ensure that the designed solution matches the end user's needs. They will also be used to determine how successful the solution is when it is finally evaluated.

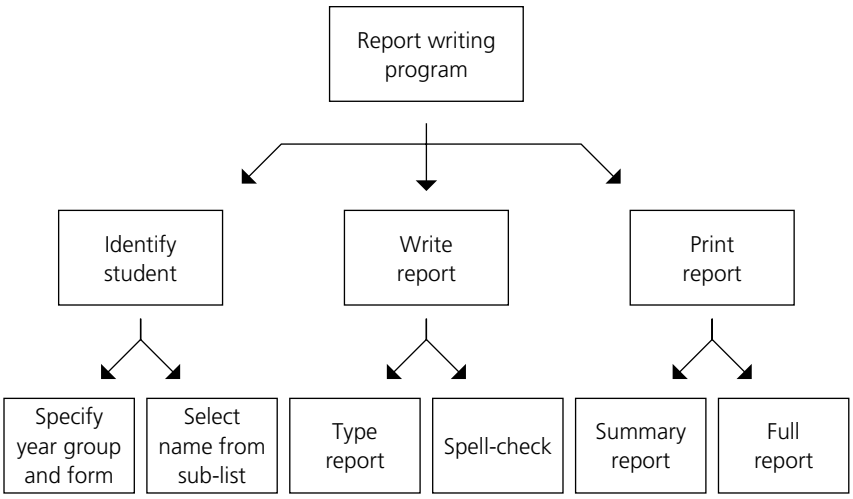
Performance criteria can be qualitative or quantitative. Qualitative criteria depend on opinion rather than on measurable outcomes. This makes them difficult to use to help test or evaluate the solution. An example of a qualitative criterion is 'The system should be easy to use'.

Quantitative criteria involve measurable outcomes. They are easier to use for evaluation and as a guide for designing a test plan. Most qualitative criteria can be turned into quantitative. An example of a qualitative criterion is 'A previously inexperienced operator will be able to enter delivery data and produce an updated stock report after 15 minutes' training'.

## Design

Most large ICT systems are designed by a team of people. So, the design must be carefully structured so that when the parts from the different members of the team are put together they work as a system.

One design method that is widely used is called top-down design. The overall problem is broken down into a series of sub-problems. Each sub-problem is then broken down into smaller sub-problems. This process is continued until the problems being identified are small and self-contained. Each sub-problem can then be solved with everyone aware of where it fits into the overall solution.




*A top-down design to produce a computer program for teachers for writing reports on their students*

In the design stage, input and output layouts are designed, both for printed and for screen-based input and output. The underlying structure of the solution is fixed. This will involve planning the way in which data will be stored, what record structures will be needed and what files will hold the data.

The people who implement the system may not be the same people who produce the design. The design must be complete enough to allow the second team to be able to implement the solution without any further information. The output from the design stage will include:

- Input and output layout sheets.
- File structures.

- Validation rules.
- Details of how any computer programming is to be done (algorithms).
- A test plan.

The test plan is an important part of the design. Its purpose is to allow the solution to be tested so that the end-user can be confident that the system is working as it should. This means that the test plan should include tests that show how the system works with the normal day-to-day data that it is expected to process. However, the test plan must also include tests with erroneous data to check the validation rules built into the system. It must include boundary data, ie data at the point where the result changes such as from valid to invalid. One final set of values needed for test data are values representing unusual or extreme data.

## Implementation

Implementation is the stage where the solution is actually created on the computer system. The team implementing the solution will follow the design, setting up the system exactly as planned. If problems are encountered or if the design is faulty in some way, then sections of the system may be redesigned. This may require the test plan to be modified.

## Testing

In practice, there will be some overlap between the implementation and testing stages. Some parts of the implementation can be tested before the whole system is complete and it makes sense to do this testing as early as possible.

Testing that is carried out early on might be, for example, making sure that invalid data is detected and reported, or ensuring that clicking a button on the screen results in the expected action. In other words, the initial testing is functional – making sure that the system actually works as expected. This testing is done using the test plan and test data that were produced as part of the original design.

A higher level of testing – end user testing – often follows this stage. This is also sometimes called beta (β) testing. Here the system is tested by real end users with actual data rather than data chosen by the system designers. This final stage of testing is necessary because situations and combinations of data that could not have been imagined by the designers may occur in real life.

## Changeover

When the system is known to be working, it will be put in place, thus replacing the original system. There are several ways in which this can be done. On a set date, the new system can be put online and replace the original system. This is sometimes called the big bang method. The changeover is done in one major operation. The difficulty with this is that all the data and files from the old system will have to be converted for use on the new. If the new system does not work properly, then the company may be left without any system at all.

An alternative to the big bang method is parallel running. Here the old and the new systems are both used. Gradually, more and more of the workload will be transferred to the new system. This means that if there are initial problems with the new system then the old one can still be used. However, it is more expensive to run two systems at once to do the same job and there is more chance of confusion or error if the two different systems are run side by side.

## Evaluation

The final phase of the system life cycle is the evaluation of how successful the new system is. This is done by measuring the performance of the system against the original performance criteria agreed during the analysis stage.

Evidence that the system meets these criteria will be partly provided by reference to the testing stage, since the design and the test plan were both developed with the performance criteria in mind.

## Documentation

A variety of written reports and documentation are produced during the design of the system. The documentation is necessary for three different groups of people:

- The team producing the system will need technical documentation.
- The people who install and maintain the system will need technical documentation.
- The user will need documentation to tell them how to use the system.

Technical documentation includes the following:

- **System design** – Used by the team implementing the system in order to create it. This will consist of layout diagrams for input and output, descriptions of computer code, file structures and validation rules. This documentation will also be used if the system fails to work properly (corrective maintenance), if it needs to be expanded (adaptive maintenance), or just made to work more efficiently (perfective maintenance).
- **Test plan** – Used by the team testing the system. It will consist of test data and the expected result or output. When testing is complete, then the actual result or output will also be given.
- **Installation guide** – This will be used by the team that sets the system up for changeover. It will include details of how any software should be set up, how data can be transferred from the existing system and what hardware is needed to run the system.

The purpose of the user documentation is to explain how to operate it. This documentation is often called a user guide. It may come in several parts. For example, there may be an initial 'getting started' section and a more detailed reference section.

The user guide may include details of how to install the system if it is not to be installed by the supplier. It will include details of how to start up and shut down the system, how to back-up data and how to carry out the normal day-to-day operations that the system was designed for. In addition, there will be sections describing infrequent operations like end of year tidying up of data.

Finally, the user guide will describe likely error situations and explain what action needs to be taken when these errors occur.

## Key points

- An ICT system is developed through a number of stages called the system life cycle.
- The system life cycle consists of analysis, design, implementation, testing, changeover and evaluation.
- A systems analyst is a specialist who works with the people running the existing system and identify what the requirements of the new system are.
- A number of different documents are produced. Some of these are technical and some are for the end user.

## Question

Five years ago a mail order company installed a computer system to handle customer orders. The company's business has expanded and they now find that the system cannot handle the number of orders that they receive each day. They contact their original supplier to find a solution.

a What stage of the system life cycle is being described here?

b What methods could the systems analyst use to investigate the problem?

c The systems analyst suggests that the existing system could be fine-tuned to cope with the increased demand. What type of maintenance is this?

d The manager of the mail order company mentions a problem with the invoicing system. It works well except on the last day of February in leap years, when the system puts an incorrect date on the invoices. What type of maintenance will be required to fix this problem?

# 9 Computers and the Law

There are two laws that were passed to deal with issues relating directly to computers. These are the Data Protection Act, 1998 and the Computer Misuse Act, 1990. In addition, there are a number of other laws and EU directives that apply to the use of computers, in particular the health and safety directives. Copyright law also applies to software – it is illegal to make unauthorised copies of computer software.

## The Data Protection Act, 1998

This Data Protection Act replaced the 1984 Data Protection Act. Both the 1998 and the 1984 Acts were passed to comply with European directives on data protection. There had been a number of concerns over the 1984 Act; it did not apply to written data, individuals had little control over the use of personal data and there were many exemptions such as pensions and payroll data that the Act did not apply to. The 1998 Act remedied some of these defects and imposed much stricter controls on the collection, storage and processing of personal data.

The 1998 Act regulates the way in which personal data is collected, stored, processed and used. The Act applies only to personal data about identifiable living individuals. The Act applies to all data that is stored within a computer system, but it also covers paper-based or manual records that are stored in a structured way (ie where information about individuals can be found).

The Data Protection Act defines three people. The **data subject** is the person whose personal details are being stored. The **data controller** is the person (or organisation) that is storing the data. The **information commissioner** is the person appointed by Parliament to ensure that the provisions of the Act are followed and is also responsible for keeping a register of all controllers.

## Data controller

Any person or organisation that stores personal data about identifiable living individuals is a data controller. Data controllers must register their use of the data with the information commissioner unless they are in an exempt category. When the data controller registers, they will complete a series of forms in which they must supply:

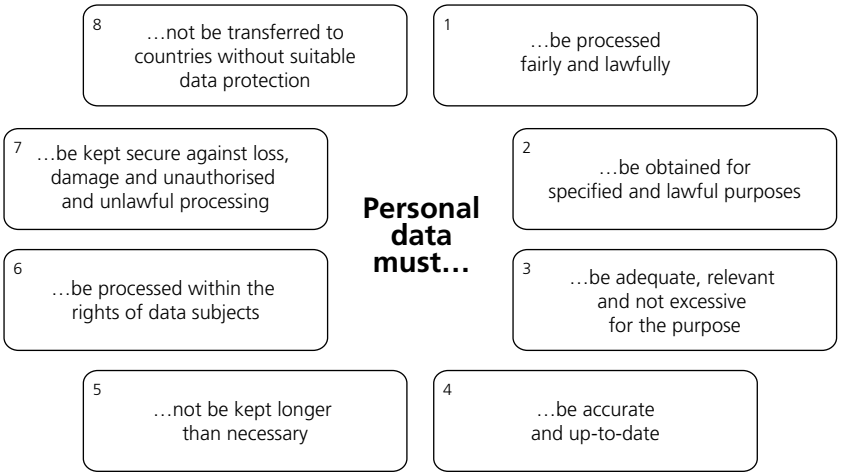
- their name and address
- a description of the data they will process
- the purposes that they are processing the data for
- where the data will be passed to
- details of other countries the data may be sent to
- a description of the security measures they will take to protect the data.

The information commissioner checks that the sources of data are legitimate, that the intended use of data is reasonable and that the data to be kept matches the intended use. Finally, the information commissioner checks that the intended destinations (if any) are in countries that also have a Data Protection Act.

Once these checks have been made, the data controller will be registered and they will be able to collect, store, process and distribute the personal data as detailed in their registration documents.

## The data protection principles

There are eight principles that a data controller has a duty to abide by when using personal data. A summary of these is shown below:




These eight principles impose eight duties on the data controller. If the data controller fails to keep them, then the information commissioner may issue an enforcement order requiring them to do so. The information commissioner can also obtain a search warrant if necessary to investigate suspected breaches of the Act.

## The subject's rights

The Act gives the data subject seven rights. These are:

- **Right of access** – The right to be told if their personal data is being processed and to be provided with a copy of the data in printed format if requested. A reasonable fee can be charged to cover administrative costs.
- **Prevention of processing** – The right to halt or prevent processing that would cause damage or distress to them.
- **Prevention of direct marketing** – The right to prevent advertising or marketing material being sent to them.
- **Prevention of automated decision-making** – The right to prevent decisions about them being made on the basis of automatic processing, eg whether or not to interview them for a job based only on a computer scan of their CV for key words.
- **Compensation** – The right to compensation if they have suffered damage or distress due to a breach of the Act.
- **Correction** – The right to have inaccurate data corrected or erased. The data subject can obtain a court order to enforce this if necessary.
- **Assessment** – The right to ask the information commissioner to see whether or not personal data is being processed in accordance with the Act.

## Exemptions

There are some situations in which it is felt that, for the benefit of society as a whole, the rights of the individual must be restricted. The Data Protection Act, 1998 either does not apply in these circumstances or else the use of the data is exempt from some part of its provision so that the data subject has fewer rights because of the exemption. The following list outlines some of the more important exemptions to the 1998 Act:

- **National security** – The data protection principles do not apply if a government minister signs an exemption certificate in order to safeguard national security. In this situation, the data subject has no rights and the information commissioner cannot enforce the Act.
- **Crime and taxation** – Where data is used for the purpose of preventing or detecting crime, to catch criminals or to ensure that proper taxes are paid, there are a number of exemptions. The purpose of these exemptions is to prevent suspected criminals using the Act to avoid detection or capture. This exemption means that if the application of the Data Protection Act would prevent the proper authorities carrying out the work of detecting and preventing crime, capturing criminals or collecting taxes then:
  - the data subject does not have the right to access their data, nor do they have to be informed that the data is being collected or processed
  - the second, third, fourth and fifth data protection principles do not apply
  - the subject cannot prevent processing likely to cause damage or distress.

  These exemptions apply only to situations where the application of the Act would hinder the proper work of the authorities. The exemptions would not apply, for example, to police records which bore no relation to ongoing or future investigations, so the Act would apply to this data.
- **Special purpose exemptions** – Some jobs would be impossible if the Act applied fully to the data they used. Journalists, for example, could be prevented from working effectively. The special purpose exemption applies to processing for publication or where the use of the data is in the public interest. In these situations, only the seventh data protection principle applies (keeping the data secure). Also, the data subject loses the following rights:
  - They have no right of access to the data.
  - They cannot prevent processing likely to cause damage or distress.
  - They have no right to have inaccurate data corrected or erased.
  - They have no right to prevent automatic decision-making based on the data.

  Of course, if lies or untrue things are published then they may be able to sue the author and publisher for libel.
- **Information available by law** – Some information has to be made available by law. Electoral registers are an example of this. In situations where the law requires information to be made available, then it is exempt from the first data protection principle. It is also exempt from the fourth and fifth principles and the data subject loses the right of access, the right to prevent processing and the right to have incorrect data changed or deleted.
- **Domestic purposes** – Personal data stored for family or household affairs (eg Christmas card lists) are exempt from the Act. The individual's rights do not apply and the information commissioner does not need to be notified of the use.

## Effectiveness of the Act

Many people are worried about the amount of personal data that is stored on computer systems. It is instinctive for people to want to preserve their privacy; no one wants their personal details to be generally available.

Personal data has always been stored. The health service, banks, etc all need to store some personal details about their customers or clients if they are to serve them properly. With the advent of computers, people became worried that personal data was more readily accessible.

A computer system can be searched to extract data about a particular individual more quickly than a paper-based system and, unlike with the paper-based system, the data can be viewed from a remote access point, perhaps in another country. Data can be removed or altered with no physical evidence. An additional worry is that data stored on a number of computers can easily be brought together to give a detailed picture of a person.

The Data Protection Act, 1984 was introduced as a result of an EC directive that aimed to protect the individual's right to privacy. Many people think that this Act was not as effective as it might have been for the following reasons:

- There were many more exemptions than under the new Act. Small clubs' members' data, payroll and pensions data, for example, were exempt from the Act.
- The Act did not give the individual any rights over their personal data. Their details could be collected, used, bought and sold by registered users and the individual had no power to prevent this.
- The Data Registrar had only a small staff to monitor the working of the Act for the whole country.
- The Act did not cover paper-based records.

The 1998 Act has reduced the number of exemptions, has given the individual important rights over the way their personal data is collected and processed, and extends the scope of data protection to include paper-based records. However, during a transitional period, the Act does not come into full operation for data that was being used before October 1998. Written records in use before this date will not be covered until October 2007 to give organisations time to bring their use of written data into line with the new Act.

## The Computer Misuse Act, 1990

This Act created three new criminal offences:

- To gain, or attempt to gain, unauthorised access to a computer system. This makes hacking a criminal offence.
- To gain, or attempt to gain, unauthorised access to a computer system with the intention of committing some further criminal act. This is a more serious offence and applies where the hacker intends to commit fraud or steal or damage data.
- To make, or attempt to make, unauthorised changes to data stored on a computer system. This offence also includes knowingly distributing viruses since these are designed to make unauthorised changes to computer data.

## Copyright law

The main copyright law in the UK is the Copyright Designs and Patents Act, 1998. This Act includes protection for computer programs and hence it is illegal to make or own unauthorised copies of software. Copyright law makes software piracy illegal.

## Health and safety law

Computers, like most equipment in the workplace, are covered by various health and safety regulations. These cover:

- The relative positioning of seat, keyboard and VDU to reduce the chance of backache and repetitive strain injury.
- The positioning of VDUs and the use of filters to ensure that light is not reflected off the screen from windows.
- The type of room lighting used – again to reduce screen reflection.
- Screening of VDUs to reduce the amount of electromagnetic radiation produced.

## Key points

- The Data Protection Act is designed to regulate the collection, use and distribution of personal data about living individuals.
- Data controllers must notify their use of personal data and abide by the eight principles of the Act.
- A data subject has the right to view their own data, to have mistakes corrected and to claim damages resulting from any breach of the principles.
- A data subject can prevent data being processed if it causes damage or distress or for direct marketing.
- There are some exemptions to the Act, which are made in the public interest.
- The Computer Misuse Act makes hacking and distribution of viruses criminal offences.
- Copyright law makes software piracy illegal.
- A number of health and safety regulations apply to computer workstations in the workplace.

## Questions

The 1998 Data Protection Act replaced the 1984 Act and was intended to provide greater protection for the data subject.

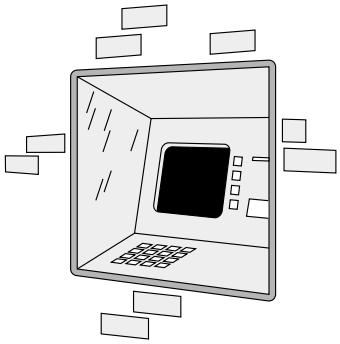
1 Discuss the ways in which the 1998 Act provides greater protection for personal data. You should describe at least three areas of improvement.

2 The right of the individual has to be balanced against the needs of society. Explain how the 1998 Act attempts to do this.

# 10 Computers and society

## The importance of ICT

ICT solutions are used in many aspects of life. Some examples are outlined below:



- **Banks** – The number of transactions processed by banks each day could not be handled manually; the volume is simply too great. The entire banking system is therefore totally dependent on ICT to operate.
- **Communications** – Communication systems depend on ICT to connect calls through computer-controlled telephone exchanges. In addition, communication systems are increasingly dependent on satellite technology, which is itself dependent on ICT.
- **Medicine** – Patient's records are computerised and their treatment is often dependent on computer-controlled apparatus. Scanners, radiotherapy machines, monitoring and alert systems all contain microprocessor chips in their control circuitry.
- **Business** – Stock control, the use of spreadsheets to model future trends and sales and the maintenance of customer records all require the use of computers.
- **Transport** – Signalling systems on railways and airport air traffic control systems all rely on computers. In addition, microprocessor chips are increasingly used to control engine performance and safety devices in cars.

Society is now so dependent on computers that it would be impossible for it to function without them. Computer failure can result in a company going out of business and, in safety critical applications, in loss of life.

## Social effects of ICT

One obvious area that the introduction of information and communication technology has affected is employment. Some jobs – particularly manual or repetitive ones – have been lost.

However, more jobs have been created in computer sales, support and software development. The nature of many jobs has changed. Work that previously could only be done after months or years of training, can now be performed with fewer skills and computer support.

Life is in many ways easier and more convenient because of computer technology. The introduction of automatic teller machines (ATMs) saves queuing at the bank and allows cash to be withdrawn at any time. Communication systems are more reliable and more widely available. Computer systems provide home entertainment and teaching facilities and the Internet allows access to a worldwide information exchange.

Computers do, however, give rise to more opportunities for crime. Computer hacking and viruses can disrupt work. Computer piracy can deprive software developers of their rightful rewards and computer failure can result in great inconvenience or even personal danger.

Many people are worried that the widespread use and interconnection of computer systems will lead to an unacceptable loss of privacy. Personal details can be bought and sold, resulting in junk mail, which some people consider an intrusion. Computer security systems can recognise and monitor the movements of individuals and, although this may help in the detection and prevention of crime, the information could be used by an unscrupulous or corrupt state to restrict personal freedom.

Computers are also blamed for a decrease in personal contact. Communicating by email, surfing the Internet and spending hours working or playing on a computer system all remove people from direct human-to-human interaction.

## Who stores what?

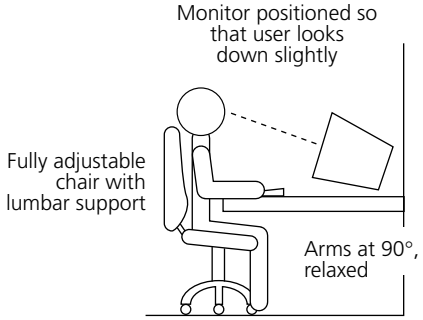
A large number of organisations store personal data about you and your family. In most cases, the data will include your name, address and telephone number. The list below gives some of the additional data stored by a few of the many organisations that keep personal data about customers or clients:

- **Doctor** – Medical history, allergies, repeat prescriptions, dates and types of inoculations, current treatment, results of tests.
- **School** – Parental status (married, separated, divorced, etc), emergency contact details, previous schools attended, examination results.
- **Bank** – Details of payments made from the account, details of deposits, loan details, overdraft limit, details of when and where you used your cash point card, information about standing orders and direct debits.
- **Supermarket** – Data is collected every time you use a loyalty card, hence information is held regarding how much you spend each week, what you buy, what days and times you visit the supermarket.

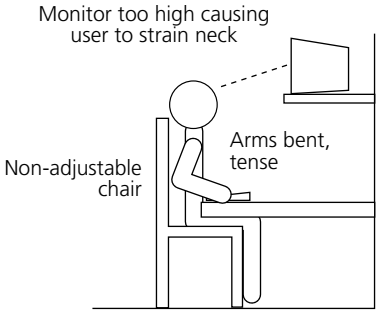
There are many other organisations who also store personal details.

## Health and safety issues

People using computer systems for long periods of time may suffer specific health problems unless the way they work and their working environment are properly designed. Employers have a duty under the Health and Safety at Work Act to look after the health of their workforce. In addition, there are other regulations that require equipment such as VDU screens to meet minimum standards.




*A healthy working position*




*A poor working position*

The table on page 55 highlights some potential problem areas and identifies what can be done to eliminate, or at least reduce, the possibility of health problems for those workers who spend a significant part of their working day using a computer:

| Potential health problem | Possible solutions |
|---|---|
| Eye strain from long periods using a VDU. | The employer should:<br>• provide free eye tests and glasses, if necessary<br>• install special lights in room to reduce screen reflection<br>• provide screen filters to increase contrast and reduce reflection<br>• position the VDU screen or use blinds to reduce reflection from windows<br>• use Ôflat screen' LCD displays to eliminate screen flicker |
| Repetitive strain injury (RSI). Wrist or hand pain caused by fingers repeatedly hitting the keyboard. | • have correctly positioned keyboards and adjustable chairs so that the angle between the wrist and hand is correct<br>• provide wrist supports<br>• allow workers to take regular breaks |
| General aches and pains (eg backache). | • provide swivel-mounted VDUs, fully adjustable chairs and use of foot rests so that the working position is comfortable |
| Electromagnetic radiation from VDU screen. | • use LCD displays which do not emit radiation<br>• use VDU screens with low emissions, meeting a minimum legal standard. |

Besides the problems outlined above, employers need to protect against the hazards that are associated with any electrical equipment. Power leads should not be left trailing for people to fall over, correct fuses should be fitted to plugs and equipment should be disconnected if electrical faults are found.

## Key points

- Society is now totally dependent on ICT.
- ICT provides many benefits in terms of jobs, the standard of living and quality of life.
- ICT also has a negative side in increased opportunities for crime, loss of work in some areas and possible loss of social interaction.
- Many organisations store large amounts of personal data.
- Some people are worried that personal data may be misused or lead to a loss of privacy.
- There are health concerns for people who spend a lot of time using a computer.

## Questions

1 Describe three possible health hazards which could arise from long-term use of a computer system and mention ways in which any risk could be reduced.

2 Collect two forms that two different organisations or businesses use to collect personal data. (For example, a magazine subscription form, a competition entry form or a school admission form.) Draw up a table showing what personal data each form is collecting. Beside each piece of data, write why you think the organisation needs it and whether you think it is necessary for them to collect it.

# Glossary

| | |
|---|---|
| **Automatic teller machine (ATM)** | Cash machine. |
| **Back-up** | The process of keeping files and data so that a working copy of a current file can be recreated if the file is corrupted, damaged or lost. |
| **Bar code** | A series of black and white strips of varying widths that represent a number. |
| **Batch processing** | A system of file processing where transaction data is collected in a transaction log and processed together in a single batch. |
| **Browser** | A computer program that downloads and displays Web pages. |
| **Bus network** | A method of connecting computers together so that they all share a single network cable. Only one computer at a time can send data along the cable. |
| **Command language** | A special language which the user learns to communicate instructions to the computer system. |
| **Data logging** | The process of using a computer system to collect physical data. |
| **Email** | An electronic message sent to an address to be stored on a central computer. The message can be downloaded and read by the recipient. |
| **Encryption** | Changing data in an apparently random way, based on a key, so that the data appears meaningless. |
| **Feedback** | Where the output from a system affects the subsequent input. |
| **File server** | A central computer on a LAN that stores data and software for all network users to access. |
| **Generations** | Grandfather, father and son versions of the same file. The son generation is the latest version and will be used in processing. The father and grandfather are kept for back-up purposes. |
| **Global ICT service** | Any ICT service where the provider and customer can be based in different countries. |
| **Graphical user interface (GUI)** | An HCI that uses graphics in the form of icons to help communicate with the user. |
| **Human–computer interface (HCI)** | The mixture of hardware and software that allows the user to communicate and interact with the computer. |
| **Hyperlink** | An active part of a page which, when clicked on, causes the destination page to be loaded and displayed. |
| **Internet** | A large number of networks linked together. It is a worldwide source of information. |

| | |
|---|---|
| **Integrated services digital network (ISDN)** | A service that allows digital data to be transmitted without the need for a modem. The speed of data transmission is many times faster than for a normal telephone line. |
| **Language** | A computer language is a system of words that can be used to give instructions to a computer. |
| **Light-dependent resistor (LDR)** | Light sensor which changes its electrical resistance according to the amount of light falling on it. |
| **Local area network (LAN)** | A local area network, which connects computers within a single room, building or site. |
| **LOGO** | A computer language that can be used to control the movements of a 'turtle' as it draws on the screen. |
| **Loop** | A set of instructions in a computer program that repeats several times. |
| **Magnetic ink character recognition (MICR)** | Characters are recognised by their effect on a magnetic field. |
| **Magnetic strip card** | A plastic card with a magnetic strip stuck to the back. Data is stored on the strip. |
| **Menu** | A list of options that are available to the user. The user selects one of the options with a mouse, by pressing a key or, with touch screen systems, by touching the screen. |
| **Merge** | The process of combining data from records in two files to create a new file. |
| **Mesh network** | A method of connecting computers together so that there are a number of direct connections between them. |
| **Modem** | Short for modulator-demodulator. A device that converts the on/off pulses used by computer systems into a form that will travel efficiently down a long cable. It is also responsible for converting the signals back to pulses at the other end of the cable. |
| **Network** | A number of computers connected together so that they can exchange data and share other resources. |
| **Online system** | A transaction processing system. This is called online because the transaction is processed by equipment connected directly to the computer system. |
| **Optical character recognition (OCR)** | Characters are scanned and recognised by reflecting light off them. |
| **Optical mark reader (OMR)** | Detects marks made on paper. The reader scans across the paper with an infra-red light. Where there is no mark, there is a strong reflection of light; where a mark has been made, the reflection is reduced. |

| | |
|---|---|
| **Packet switching** | A system of splitting up the data to be transmitted through a network into small packets. The packets have additional data added to identify their sequence number, source address and destination address. Each packet then travels individually to the destination where the original data is reassembled. |
| **Printer server** | A computer that handles the printing of jobs stored in a print queue. |
| **Procedure** | A named set of instructions that can be saved and reused. |
| **Program** | A set of instructions written in a computer language that tells the computer to carry out a particular task. |
| **Random access** | A type of file access that allows individual records to be processed in any order, without needing to access any other record. |
| **Real time** | Any system where data is updated as soon as transactions occur. |
| **Relay switch** | A special type of switch that allows a low voltage and low power device to turn a high voltage, high power device on or off. |
| **Search engine** | A specialised Web site that maintains an index of other Web sites and that can match sites to key words entered by the user. |
| **Sensor** | A device that allows a computer system to measure a physical quantity or detect a physical event. |
| **Sequential access** | A type of file access in which each record in the file is processed in turn. |
| **Smart card** | A plastic card with memory circuits embedded in it to store data. |
| **Sorting** | The process of rearranging records in a sequential file so that they are in a particular order. |
| **Spike** | A sudden change in voltage in the electrical power supply. Spikes can be caused when something connected to the supply is turned on or off. |
| **Thermistor** | A temperature sensor. |
| **Transaction** | An event that makes it necessary to update the data in a file. |
| **Transaction file** | A file containing data waiting to be processed in a batch processing system. |
| **Transaction log** | A file containing details of all transactions that have changed data in a random access master file since the last copy of the master file was made. |
| **Transaction processing** | A system of file processing where records are updated as soon as a transaction relating to them occurs. |

| | |
|---|---|
| **Uninterruptable power supply (UPS)** | A piece of hardware that automatically cuts in to provide the computer with electrical power if the mains supply fails. |
| **Update** | The process of merging a master file with a transaction file so that the data in the master file represents the latest situation. |
| **Validation** | Checking data to make sure that its value is reasonable or possible. |
| **Wide area network (WAN)** | A network connecting computers that are in different cities, countries or continents. |
| **Windows, icons, mouse and pull-down menus (WIMP)** | A graphical interface system that uses these components to interact with the user. |